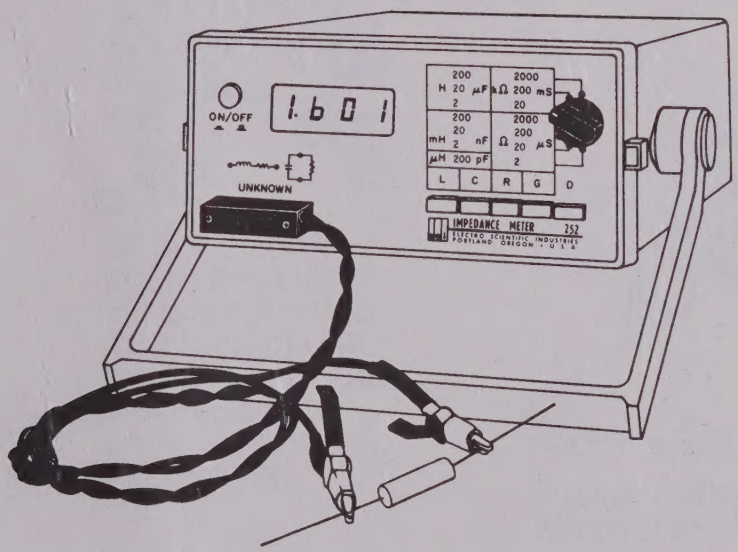
**Instruction Manual**

OCTOBER 1979
Replaces June 1979

# MODEL 252

## *Digital Impedance Meter*




Part Number 43158

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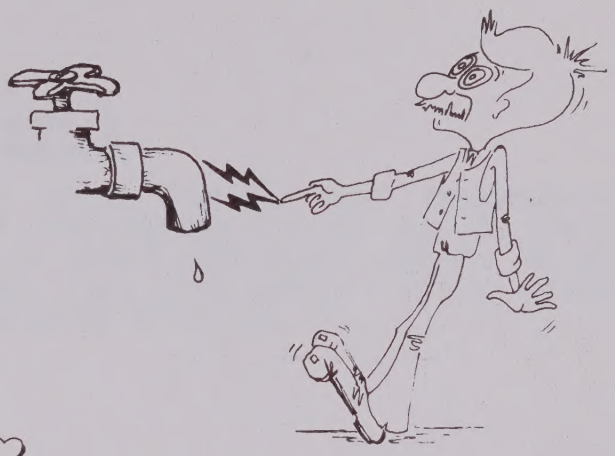
# PROTECT AGAINST ELECTROSTATIC DISCHARGE

In this instrument there are MOS and FET semiconductors, which can be damaged by electrostatic discharge during handling. The following precautionary procedures are recommended to minimize this possibility.



DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES

HANDLE STATIC SENSITIVE DEVICES ONLY AT A GROUNDED, STATIC-FREE WORK STATION

HANDLE DEVICES BY THE BODY. DO NOT TOUCH THE DEVICE LEADS.

BE SURE YOUR SOLDERING IRON TIP IS GROUNDED AND DO NOT USE SOLDER-SUCKERS THAT ARE NOT ANTI—STATIC PROTECTED

AVOID HANDLING WHENEVER POSSIBLE

USE ANTI-STATIC PACKAGING FOR HANDLING AND TRANSPORT

KEEP PARTS IN MANUFACTURER'S PROTECTED CONTAINERS

DO NOT SLIDE STATIC SENSITIVE DEVICES OVER ANY SURFACE AND AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREAS

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**WARNING**

**DANGEROUS VOLTAGE POTENTIALS EXIST INSIDE THIS INSTRUMENT. MAINTENANCE INSTRUCTIONS WITHIN THIS MANUAL ARE FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID ELECTRICAL SHOCK, DO NOT ATTEMPT ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATION INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.**


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# SECTION 1
# DESCRIPTION

## 1.1 INTRODUCTION

The ESI Model 252 Digital Impedance Meter is a semi-automatic instrument which permits rapid measurement of inductance (L), capacitance (C), resistance (R), conductance (G) and dissipation factor (D) at a test frequency of 1kHz. Measurement accuracy and versatility satisfies most demanding engineering or scientific applications.

To operate, merely push the button for the desired function, manually turn the knob to the desired range, and connect the unknown. KELVIN KLIPS® test leads are included, thus ensuring true four-terminal connections. The position of the range switch, used in conjunction with the desired function button and front panel range scale, indicate the unit of measurement being displayed by the 3-1/2 digit LED readout.

Excellent reliability of the Model 252 is assured through use of solid state devices and etched circuit board construction. Its small size is ideal for use on benchtops where work space may be at a premium. The carrying handle tilts the unit to a convenient viewing angle. Rear panel brackets provide line cord storage and enable it to be operated in a vertical position.

## 1.2 SPECIFICATIONS

| | | Ranges | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Full Scale Values | $L_S$ | 200 µH | 2 mH | 20 mH | 200 mH | 2 H | 20 H | 200 H |
| | $C_P$ | 200 pF | 2 nF | 20 nF | 200 nF | 2 µF | 20 µF | 200 µF |
| | $R_S$ | 2 Ω | 20 Ω | 200 Ω | 2 kΩ | 20 kΩ | 200 kΩ | 2000 kΩ |
| | $G_P$ | 2 µS | 20 µS | 200 µS | 2 mS | 20 mS | 200 mS | 2000 mS |
| | D | 1.999 | | | | | | |
| Accuracy (15°C to 35°C) | $L_S$ | ±[0.25% + (1 + 0.002$R_S$*) digits] ** | ±[0.25% + (1 + 0.001$R_S$*)digits] | | | | | ±[0.25% + (1 + 0.002$R_S$*) digits] |
| | $C_P$ | ±[0.25% + (1 + 0.002$G_P$*) digits] ** | ±[0.25% + (1 + 0.001$G_P$*)digits] | | | | | ±[0.25% + (1 + 0.002$G_P$*) digits] |
| | $R_S$ | ±[0.25% + (1 + 0.002$L_S$*) digits] | ±[0.25% + (1 + 0.001$L_S$*)digits] | | | | | ±[0.25% + (1 + 0.002$L_S$*) digits] |
| | $G_P$ | ±[0.25% + (1 + 0.002$C_P$*) digits] | ±[0.25% + (1 + 0.001$C_P$*)digits] | | | | | ±[0.25% + (1 + 0.002$C_P$*) digits] |
| | D | ±(1% + 0.002) for L or C ⩾ 200 counts<br>±(2% + 0.010) for L or C 50 to 199 counts | | | | | | |
| Test Signal | Voltage $C_P$, $G_P$ | 1.0 VRMS | | 0.1 VRMS | | | | |
| | Current $L_S$, $R_S$ | 100 mA | 10 mA | 1 mA | 100 µA | 10 µA | | 1 µA |

*Digit count, same range.
**After correction for test lead zero reading.
0°C to 15°C and 35°C to 50°C: add 0.1(rated accuracy)/°C.

Table 1-1. Model 252 Specifications

Test Frequency: 1kHz ±1%.

Unknown Excitation: The 1kHz voltage (Vx) and current (Ix) levels listed in Table 1-1 are held constant by an internal amplitude control circuit.

Measurement Rate: Four per second; one second is required for first reading after connecting unknown to terminals.

Measurement Display: 3-1/2 digit LED with decimal point. Blanked for overload conditions.

Unit Display: Unit of measurement being displayed by the LED readout is indicated by position of the range switch, used in conjunction with the desired function button and the front panel range scale.

External Bias: Rear panel terminals are provided for connection of external supply. 0V to 50VDC, 0.1A maximum. (Read Section 2.2.6 before using external bias.)

Static Charge Protection: Diode and resistor discharge network.

Connection to Unknown: Four-terminal, shielded, connections are provided by the KELVIN KLIPS® cable assembly (ESI Part Number 43072) supplied with the Model 252.

Outputs: Analog signals of 1V per 1,000 counts, 1kΩ source resistance is available at rear panel. L, C, R, or G, with simultaneous output of D for L or C.

Power Consumption: 4 watts typical.

Power Requirements: 100 to 125V or 200 to 250V, 50/60Hz.

Fuse: 1/16A, 250VAC, Type MDL Slo-Blo.

Size: Height (with feet) - 100mm (4 in.)
Width - 260mm (10 in.)
Depth (overall) - 370mm (14.6 in.)

Weight: 3.2kg (7 lb).

Accessories supplied with Model 252:

| | ESI Part No. |
|---|---|
| KELVIN KLIPS® Four-Terminal Clips | 43072 |
| Instruction Manual | 43158 |

Options Available:

| | ESI Part No. |
|---|---|
| Model 1412B Universal Limits Comparator | 31412B |
| Sorting Fixture Model 2001 (low frequency) | 32001 |
| Cable Assembly (for Model 2001 connection) | 43586 |
| Front Panel Dust Cover | 43374 |

# SECTION 2
# OPERATION

## 2.1 CONTROLS AND CONNECTORS

### 2.1.1 Front Panel

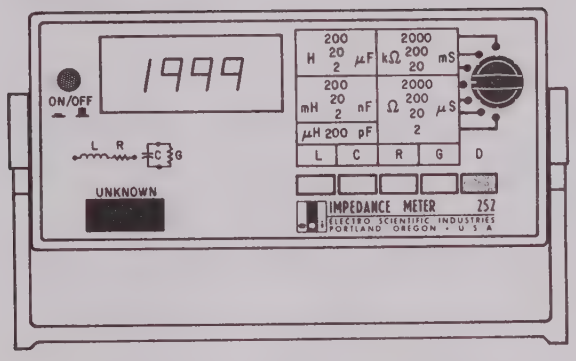



Figure 2-1. Model 252 Front Panel

1. ON/OFF Switch -- A push-on, push-off switch for applying and removing power from the instrument.

2. UNKNOWN Connector -- Terminals designed to be used with KELVIN KLIPS® test leads (ESI Part No. 43Ø72), provided with Model 252, to provide a true four-terminal connection to the unknown or test fixture.

3. L, R, C, and G Pushbuttons -- Function pushbuttons select the type of meter circuit that will measure series inductance (L) and resistance (R) or parallel capacitance (C) and conductance (G).

4. D Pushbutton -- The push-to-read D (dissipation factor) pushbutton displays the D of a capacitor or inductor when the C or L function is selected.

5. Range Switch -- Selects the decimal multiplier and units of measurement for the meter circuit being used. The basic multipliers and units are: H (henrys), mH (millihenrys), μH (microhenrys), μF (microfarads), nF (nanofarads), pF (picofarads), kΩ (kilohms), Ω (ohms), mS (millisiemens), and μS (microsiemens).

6. Display -- A 3-1/2 digit readout for all functions.

7. Tiltstand Handle -- Aids portability; tilts instrument for easier viewing of the LED display.

## 2.1.2 Rear Panel

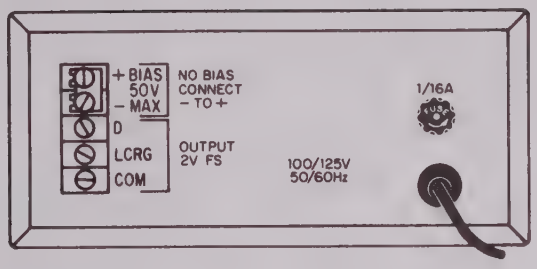



Figure 2-2. Model 252 Rear Panel

1. Bias Terminals -- Allows application of a 2V to 50VDC, 0.1A maximum bias to the capacitor being measured. (The shorting bar must be in place when not using bias feature.) See section 2.3.6 before using external bias.

2. Output Terminals -- Provides two analog signals proporational to the function selected (L, R, C, or G) and D (for L and C). These terminals can be used with external DVM's (for increased full scale readings or resolution capability), with chart recorders, or with limits comparators, such as the ESI Model 1412B.

3. Fuse -- A 1/16A, 250V, type MDL Slo-Blo is required.

## 2.2 OPERATING PROCEDURE

### 2.2.1 Power Requirements

Before turning the power ON, make sure the instrument is set to the proper line voltage. The Model 252 contains an internal slide switch to select the nominal line voltage (see Figure 2-3). In its up position, the switch selects 100 to 125VAC, 50/60Hz operation. In the down position it selects 200 to 250VAC, 50/60Hz operation.

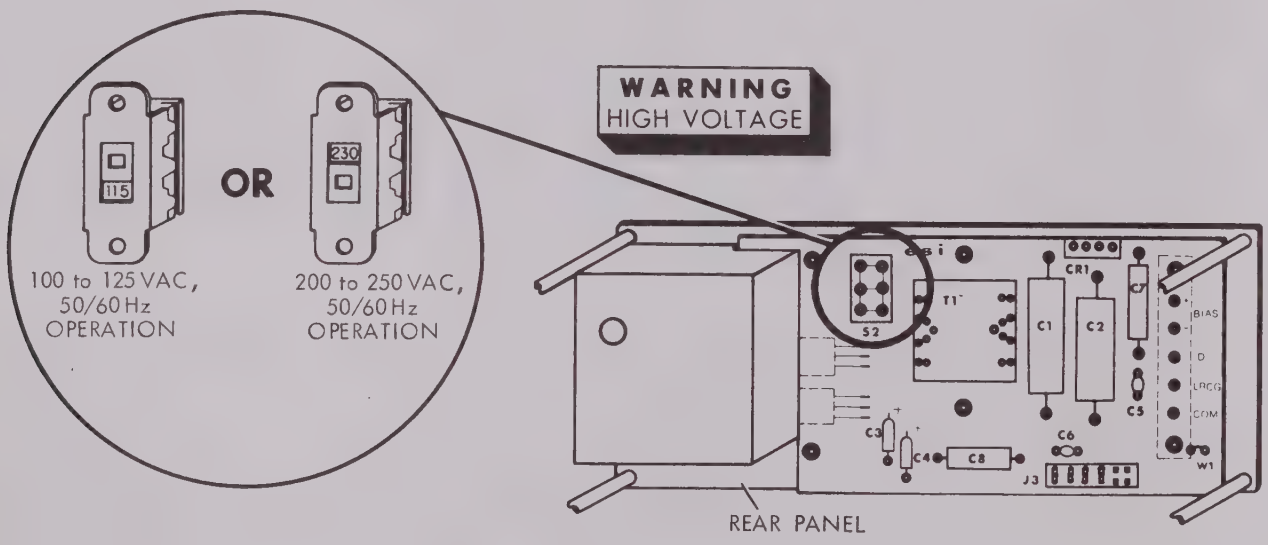



Figure 2-3. Line Voltage Switch

Because of differing power requirements, all instruments shipped outside the United States are without a power cord connector. When placing a connector on the power cord, care must be taken to assure the wires are connected properly. The green or green with yellow stripe wire is always connected to earth ground. The white or light blue wire is connected to the neutral side of the power line. And, the black or brown wire is connected to the high side of the power line.

| CONDUCTOR | COLOR | ALTERNATE COLOR |
|---|---|---|
| Ungrounded Line | Black | Brown |
| Neutral Grounding | White | Light Blue |
| Earth Grounding | Green | Green-Yellow |

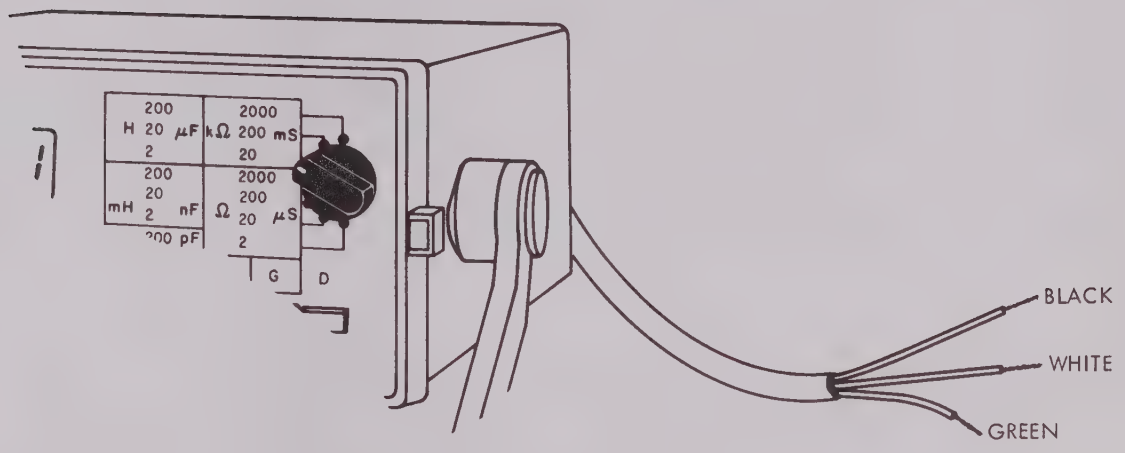



Figure 2-4. Power Cord

### 2.2.2 Applying Power

The push-on, push-off, ON/OFF button in its depressed position applies power to the measurement circuitry. When power is applied, the LED display lights and reads zero when in C and G modes or the display is blank with the decimal point lit in the L and R modes.

### 2.2.3 Connection to Unknowns

The KELVIN KLIP® test lead set (ESI Part No. 43072) is plugged into the 252's front panel UNKNOWN connector. The test leads connector cover is spring-locking and should be squeezed together before inserting or removing.

The test leads provide a shielded, four-terminal connection to the unknown (see Figure 2-5a). The clip with the red hinge-spool provides the HI DRIVE and HI SENSE connections to the unknown and the clip with the black hinge-spool make the LO DRIVE and LO SENSE connections.

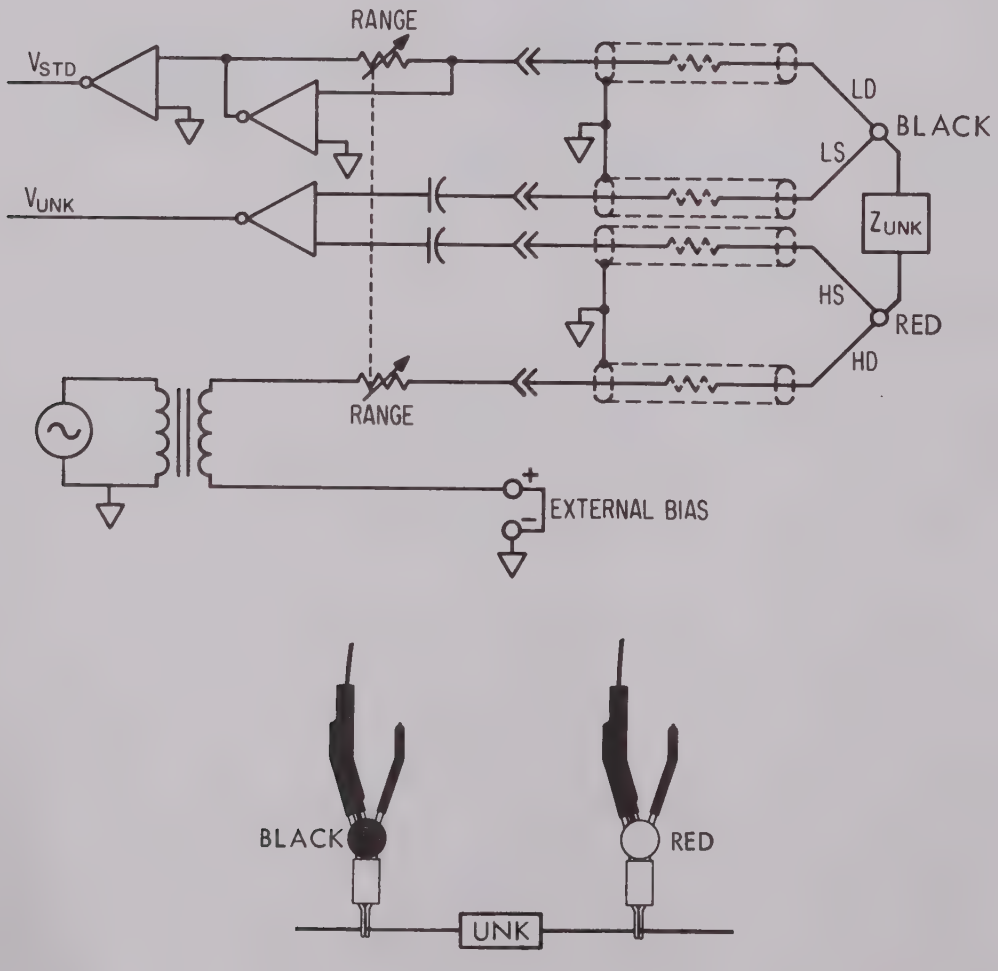



Figure 2-5a.

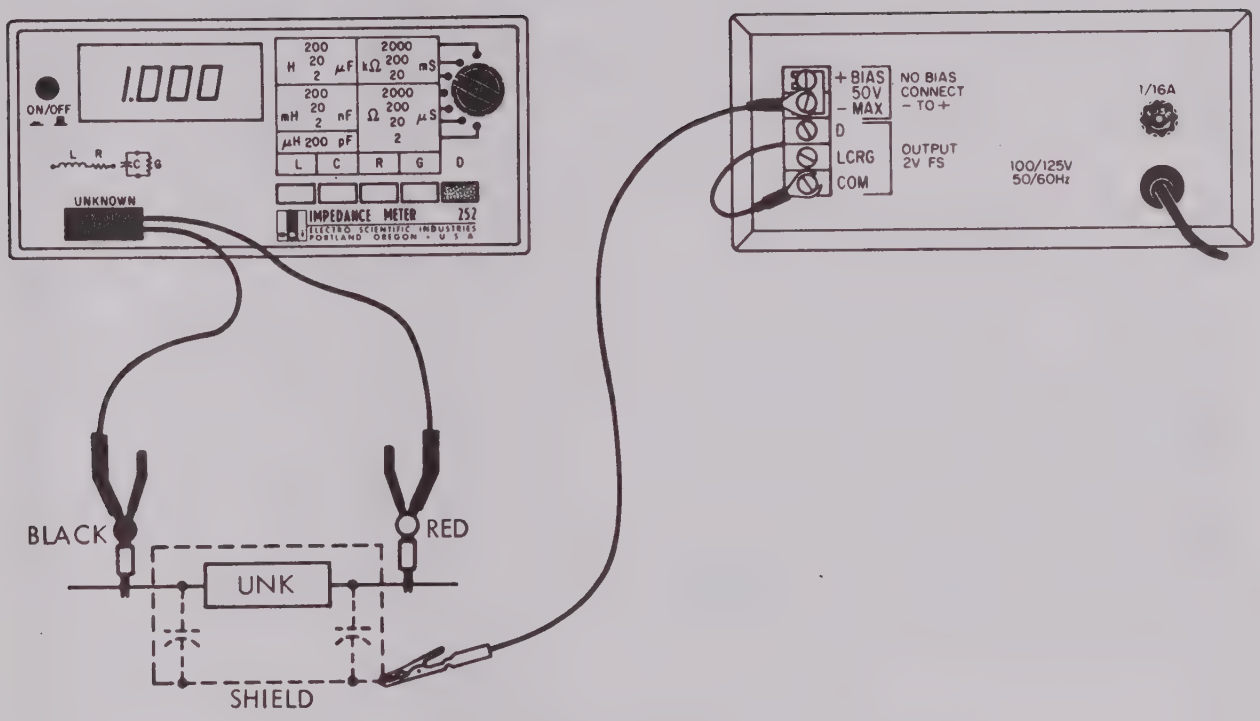



Figure 2-5b.

For connection to three terminal unknowns (the third connection is to ground), a ground wire must be added to the test lead set. This wire is connected as in Figure 2-5b.

### 2.2.3.1 Test Fixture Compensation

The Model 252 uses a 3.3pF capacitor (C6 in Figure 2-6) to compensate for the capacitance of the test leads. If the 252 is used with a test fixture, the larger capacitance of the fixture must also be compensated for. There are two methods for compensating this larger capacitance. The first method is to make a zero capacitance measurement with the test fixture connected. This reading is mentally subtracted from all other measurements.

The second method for compensating the larger capacitance is to change the value of C6 from 3.3pF to 10pF and to add an external trim capacitor. The external trim capacitor is connected in parallel with the unknown and should be of such a value that the test fixture capacitance can be trimmed to zero. Typically, the maximum value of this trim capacitor is 15pF. The trim capacitor can either be added to the test cable, between Terminals 1 and 3 of the connector as shown in Figure 2-6, or it can be added to the test fixture.

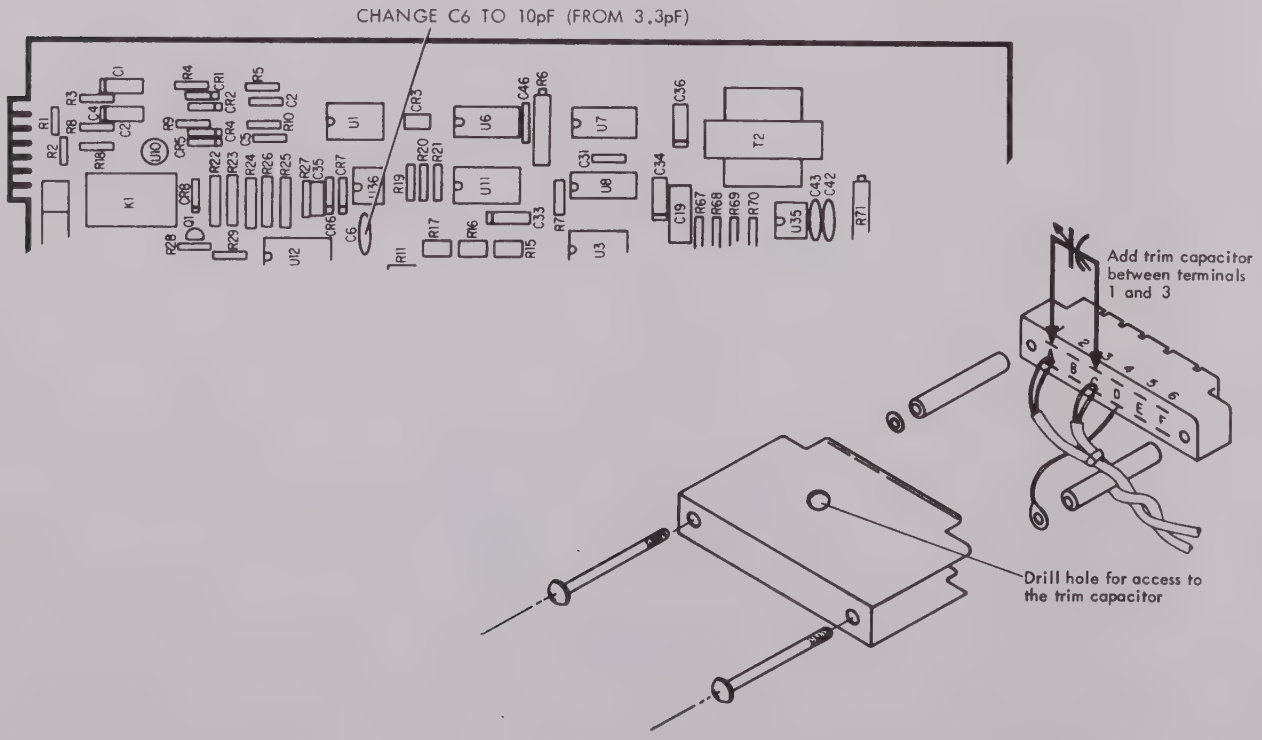
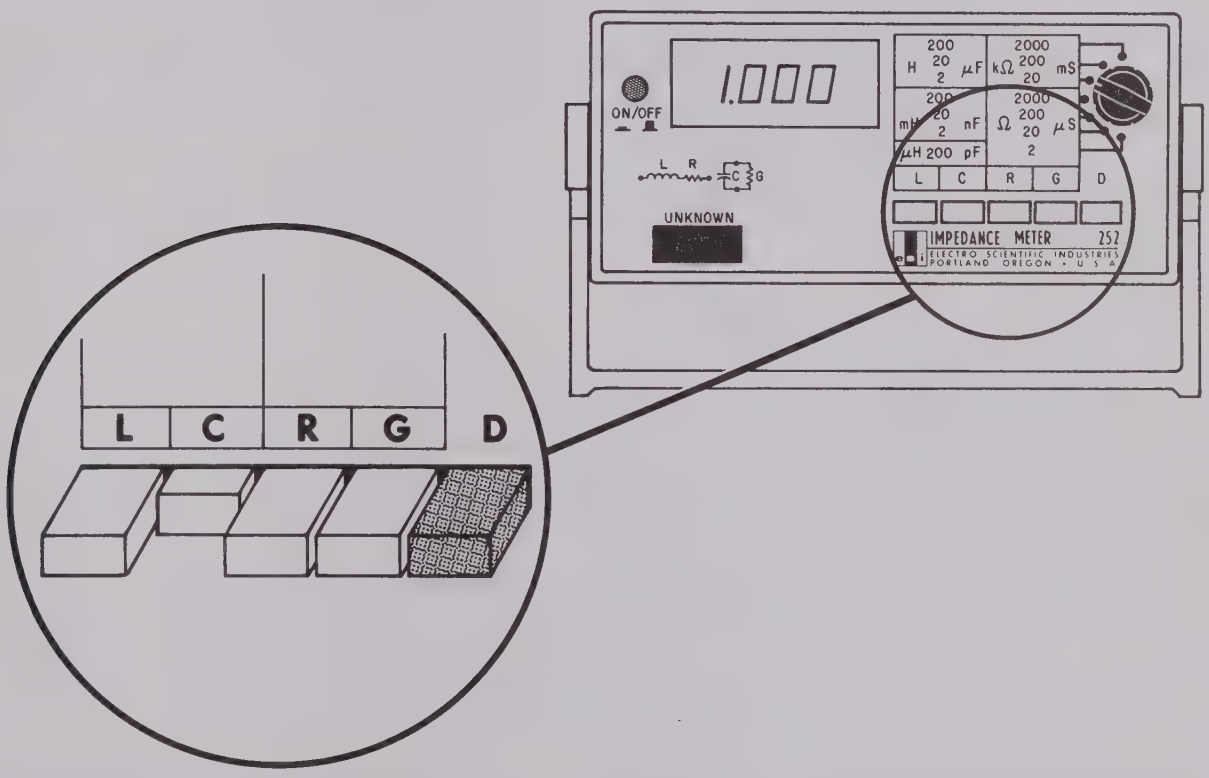



Figure 2-6. Test Fixture Compensation

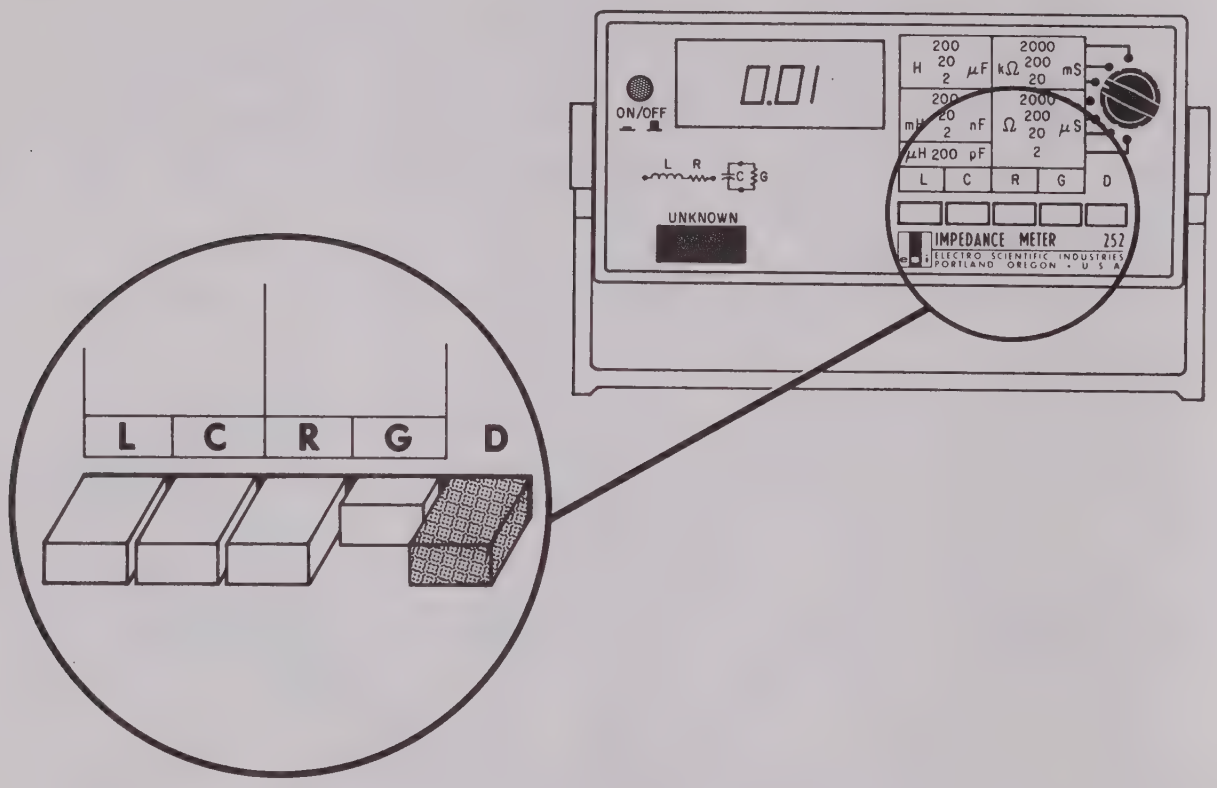
### 2.2.4 Function Selection

Model 252 is designed to measure series inductance (L), parallel capacitance (C), series resistance (R), parallel conductance (G), and dissipation factor (D) of inductance and capacitance. One of these measurement modes is selected by depressing the proper front panel button. (If all buttons are in their out position, the instrument reverts to the inductance measurement mode.)

Example: Select the capacitance measurement function. (Depress the C pushbutton.)



Example: Select the conductance measurement function. (Depress the G pushbutton.)




If a negative sign appears on the display when measuring an unknown, possible causes are:

-- "C" button has been pushed when measuring an inductor.

-- "L" button has been pushed when measuring a capacitor.

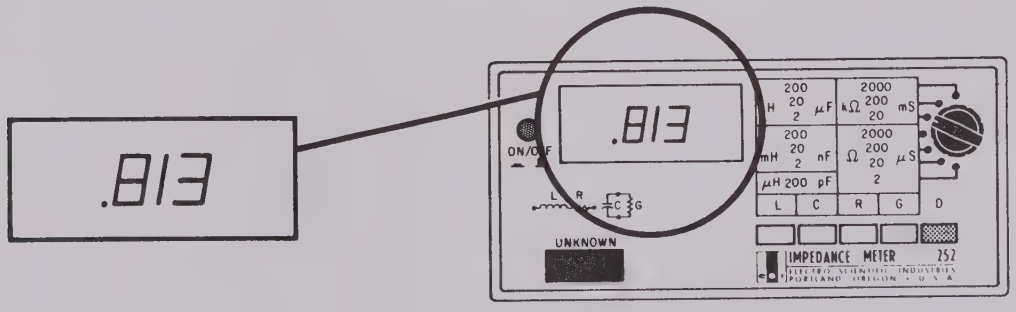
-- The unknown is more capacitive (or inductive) than suspected. For example, an inductor that resonates below 1kHz will measure as though it were a capacitor.

-- A diode requires bias voltage (a negative reading may appear if bias voltage is not applied).

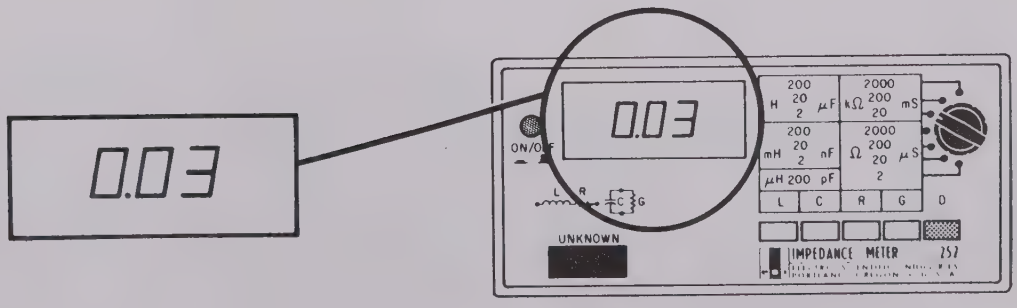
To measure the dissipation factor (D) of a capacitor or inductor, push and hold the D button while the C or L function is selected. (The display will blank if D is pushed, while the unit is in R or G mode and the unknown is resistive.)

When measuring the conductance (G) of a capacitor or the resistance (R) of an inductor, the R or G reading may be quite small. In trying to acquire more resolution by moving the range switch to the next lower range, the display will usually blank, indicating overload. Blanking occurs because the instrument is still monitoring the reactive component (L or C) in addition to measuring and displaying the loss component (R or G). In moving to the next lower range, the reactive component becomes too large for the lower range causing overload and a blanked display.

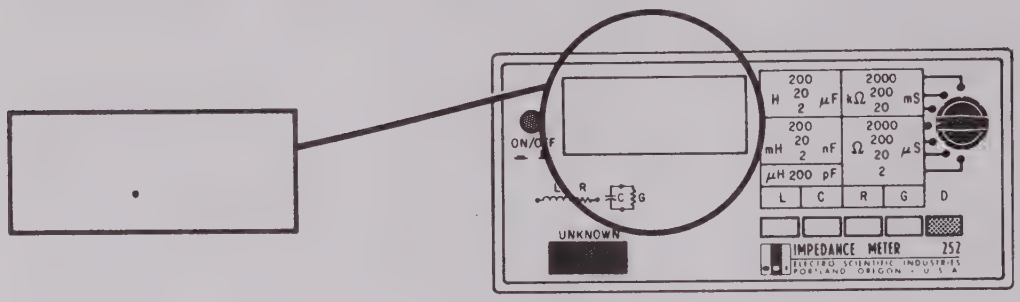
Example: While measuring a Ø.82µF capacitor using the 2µF range, the 252 display reads:




Switching to the conductance (G) mode, the display may read:



Trying further to investigate this reading, you down range from the 20mS range to the 2000µS range. The display blanks:




The display blanks because, while ranging from 20mS to 2000µS, the capacitance range changed from 2µF to 200nF. Since 0.82µF is too large to measure on the 200nF range, an overload occurs and the display blanks.

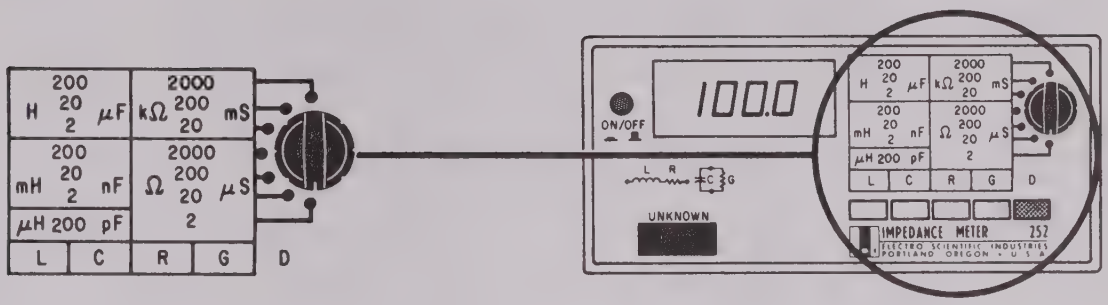
## 2.2.5 Range Selection

Measurement ranges are selected by a seven-position rotary switch. See Figure 2-7 for full-scale range values. For maximum display resolution and accuracy, select the range that gives the largest on-scale reading. The position of the range switch indicates the readout units (i.e. µH, mH, H, etc.). If either the reactive or resistive value of the unknown exceeds the range selected, the display will blank.

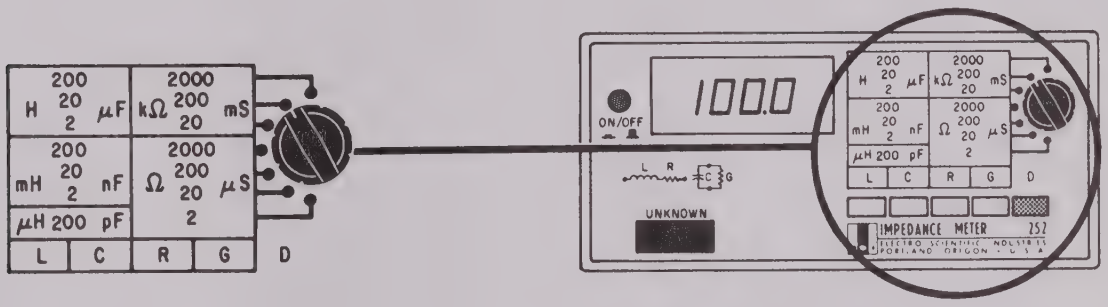
| | | Ranges | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Full Scale Values | $L_S$ | 200 µH | 2 mH | 20 mH | 200 mH | 2 H | 20 H | 200 H |
| | $C_P$ | 200 pF | 2 nF | 20 nF | 200 nF | 2 µF | 20 µF | 200 µF |
| | $R_S$ | 2 Ω | 20 Ω | 200 Ω | 2 kΩ | 20 kΩ | 200 kΩ | 2000 kΩ |
| | $G_P$ | 2 µS | 20 µS | 200 µS | 2 mS | 20 mS | 200 mS | 2000 mS |
| | D | 1.999 | | | | | | |

Figure 2-7. Range Chart

Example: Set the instrument to measure 100pF capacitors.




Example: Set the instrument to measure 100kΩ resistors.




If the value of a component is not known, set the instrument to its highest range before connecting the test leads. Step the instrument down one range at a time until the range with the highest resolution is reached. If the display is blank after the component is connected, the value of the component is too large to measure directly, see Section 2.3 for alternate measurement techniques.

### 2.2.6 Summary of Operation

Press the appropriate function button (L, C, R, or G) and connect the KELVIN KLIPS® to the unknown. For maximum accuracy, select the range that gives the largest on-scale reading. The measurement is displayed after one second or less. Repetitive measurements are made at the rate of four per second. The position of the range switch indicates the readout units (i.e. μH, mH, H, etc.). If the value of the unknown

exceeds the range selected, the display will remain blanked. To measure the dissipation factor of a capacitor or inductor, push and hold the D button while the C or L function is selected.

## 2.3 MEASUREMENT TECHNIQUES

### 2.3.1 Resistance Measurements at 1kHz

When using the resistance function, the maximum measurement is 1999kΩ. For measurements from 1999kΩ to 1000MΩ, use the G (conductance) function where G=1/R or R=1/G. Measurement accuracy is determined by ±(0.25% + 1 digit) where 1 digit will be ±100% at 1000MΩ, ±10% at 100MΩ, and ±1% at 10MΩ.

High-value, bobbin-type, wire-wound resistors have shunt capacitance which may affect measurements by appearing as "$-L_s$". This causes some difference between AC and DC resistance measurement values.

The resistive component (Rs) of inductors and transformers, when measured at 1kHz, will differ from the DC winding resistance. If the core material is air or low loss (e.g. powdered permalloy), the AC and DC values will be nearly equal. For laminated magnetic cores, the AC resistance will be greater than the winding resistance (sometimes much greater). This is caused by the core losses which change both with frequency and test current level.

### 2.3.2 Capacitance Measurements

**Shielded devices.** For shielded devices, the shield should be connected to the rear panel -Bias terminal to provide proper guarding.

Most two- and four-terminal cables or sorting fixtures are not guarded immediately adjacent to where the unknown capacitor is connected, and a zero capacitance reading can change by a few picofarads whenever the ends of the cable or fixture terminals are physically moved. Always maintain the physical orientation of the leads or terminals after checking for zero capacitance. Subtract zero-capacitance reading from the capacitance reading for the unknown.

**Equivalent Series Resistance (ESR).** To measure series resistance of capacitors, use the Rs function. Series resistance will be displayed on the front panel.

**Series Capacitance.** The Ls function can be used to measure series capacitance. (The capacitor is measured with a constant current rather than a constant voltage.) A negative reading will be shown, and the following equation must be used to convert the "-Ls" readings to the "Cs" values:

$$Cs = \frac{1}{(2\pi f)^2 (Ls)}$$

Where: f = frequency in hertz
Cs = series capacitance in farads
Ls = series inductance in henrys (ignore sign)

**Dissipation factor (D).** The D of large value electrolytic capacitors can be determined using the Ls and Rs functions using the same range. The following equation converts the Rs and Ls, in counts (ignore the sign and decimal point), to D values:

$$D = 1.59 \times \left(\frac{Rs}{Ls}\right) \text{ for 100Hz and 1kHz operation}$$

$$D = 1.33 \times \left(\frac{Rs}{Ls}\right) \text{ for 120Hz operation}$$

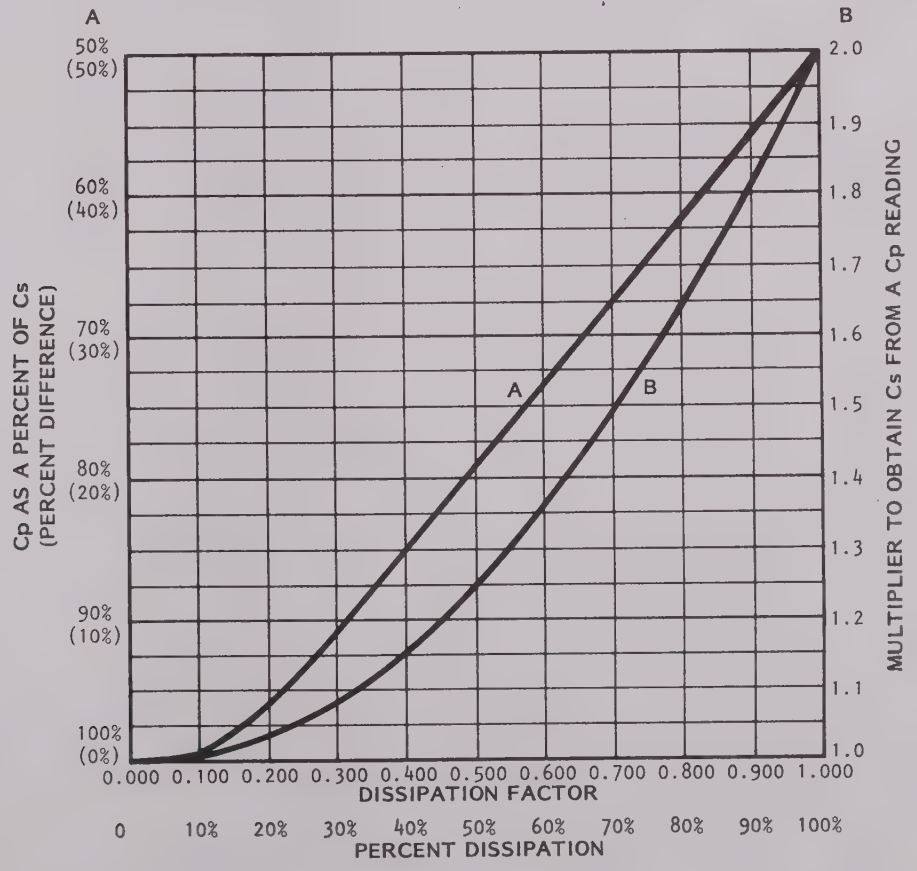
Where: D = dissipation factor
Rs = equivalent series resistance reading in counts
Ls = series inductance in counts

**Parallel Capacitance Measurements.** The relation between parallel and series capacitance measurements is:

$$Cs = (1 + D^2)\ Cp \quad \text{where } D = Gp/2\pi fCp$$

The following graph illustrates the relation between Cs and Cp. The graph is used to obtain a Cs value for a capacitor by measuring the Cp and D values of the capacitor. To locate the Cs value, find the measured D value along the horizontal axis of the graph. (The D reading from the Model 252 will be a Dissipation Factor value not a Percent Dissipation value.) Move up the graph to the B curve and read the corresponding value on the righthand vertical axis. Multiply the measured Cp value by this reading to obtain the desired Cs value.

The A curve on the graph is used with the vertical axis in the same manner as described above. The A curve and lefthand scale provide the Percent Difference between Cs and Cp.



### 2.3.3 Inductance Measurements

The 252 measures the total impedance connected to its terminals. Both the unknown inductor and its leads contribute to this impedance. The leads have some resistance and inductance which affect the value read from the meter.

In making high inductance measurements, avoid AC pickup and keep the stray capacitance to a minimum. To minimize both effects, keep hands as far as possible from the inductor being measured. Keep the leads as short and direct as possible. Take care to avoid coupling stray magnetic fields into the inductor.

For greatest accuracy on low inductance measurements, minimize the lead impedance. Closely spaced, twisted leads will reduce the inductance and pickup of stray fields. The KELVIN KLIPS® Cable Assembly will add about Ø.5μH to Ls and ØmΩ to Rs. Short the test leads together and subtract the reading from the unknown inductance measured.

Measuring leakage inductance of transformer windings is an easy task for the Model 252 since there are no "false nulls" as found in manually-balanced bridges.

### 2.3.4 Determining Quality Factor (Q) of Inductors

To determine the Q of inductors, push the D button, record the D reading and calculate Q from the equation Q=1/D. This procedure works well for Q≥Ø.5 (or D≤2). For Q≤Ø.5, measure the inductance of the unknown and record the readout display in digits only. With the RANGE switch in the same position, press the R button and note the readout display in digits, only. Do not record the decimal point or range multiplier for Ls or Rs; they are not required. Turn to Figure 2-8 for the D-Q nomograph. Use a straightedge to line up the Ls digits recorded (left-hand scale) with the Rs digits recorded (right-hand scale). Q is taken from the left-hand side of the center scale where the straightedge crosses. For example, with an Ls digital display of "3ØØ" and an Rs digital display of "6ØØ", Q is Ø.3. Accuracy of Q is primarily limited by interpolation of the nomograph.

Although the nomograph provides a convenient way to approximate Q, it may be determined more accurately by the formula:

$$Q = Ø.628 \times \left(\frac{Ls}{Rs}\right) \text{ for 1ØØHz and 1kHz operation}$$

$$Q = Ø.754 \times \left(\frac{Ls}{Rs}\right) \text{ for 12ØHz operation}$$

Where: Q = Quality factor
Rs = equivalent series resistance reading in counts
Ls = series inductance in counts

See Table 1-1 for accuracy of Ls and Rs measurements.

### 2.3.5 Determining Dissipation Factor (D) of Capacitors Using Nomograph

Model 252 will measure dissipation factor up to 1.999. For D values greater than 2 the nomograph should be used. Measure the capacitance of the unknown and record the readout display in digits only; do not record the decimal point. With the RANGE switch left in the same position, push the G button and note the readout display in digits only; do not record the decimal point. Turn to Figure 2-8 for the D-Q nomograph. Use a straightedge to line up the Cp digits recorded (left-hand scale) with the Gp digits recorded (right-hand scale). D is taken from the right-hand side of the center scale where the straightedge crosses. For example, with a Cp digital display of "200" and a Gp digital display of "300", D is 2.3. Accuracy of D is primarily limited by interpolation of the nomograph.

Dissipation factor may be determined more accurately by the formula:

$$D = 1.59 \times \left(\frac{Gp}{Cp}\right) \text{ for 100Hz and 1kHz operation}$$

$$D = 1.33 \times \left(\frac{Gp}{Cp}\right) \text{ for 120Hz operation}$$

Where: D = dissipation factor
Gp = parallel conductance reading in counts
Cp = parallel capacitance in counts

See Table 1-1 for accuracy of Cp and Gp measurements.

Electrolytic capacitors with high dissipation are usually unstable and the measured values may drift.

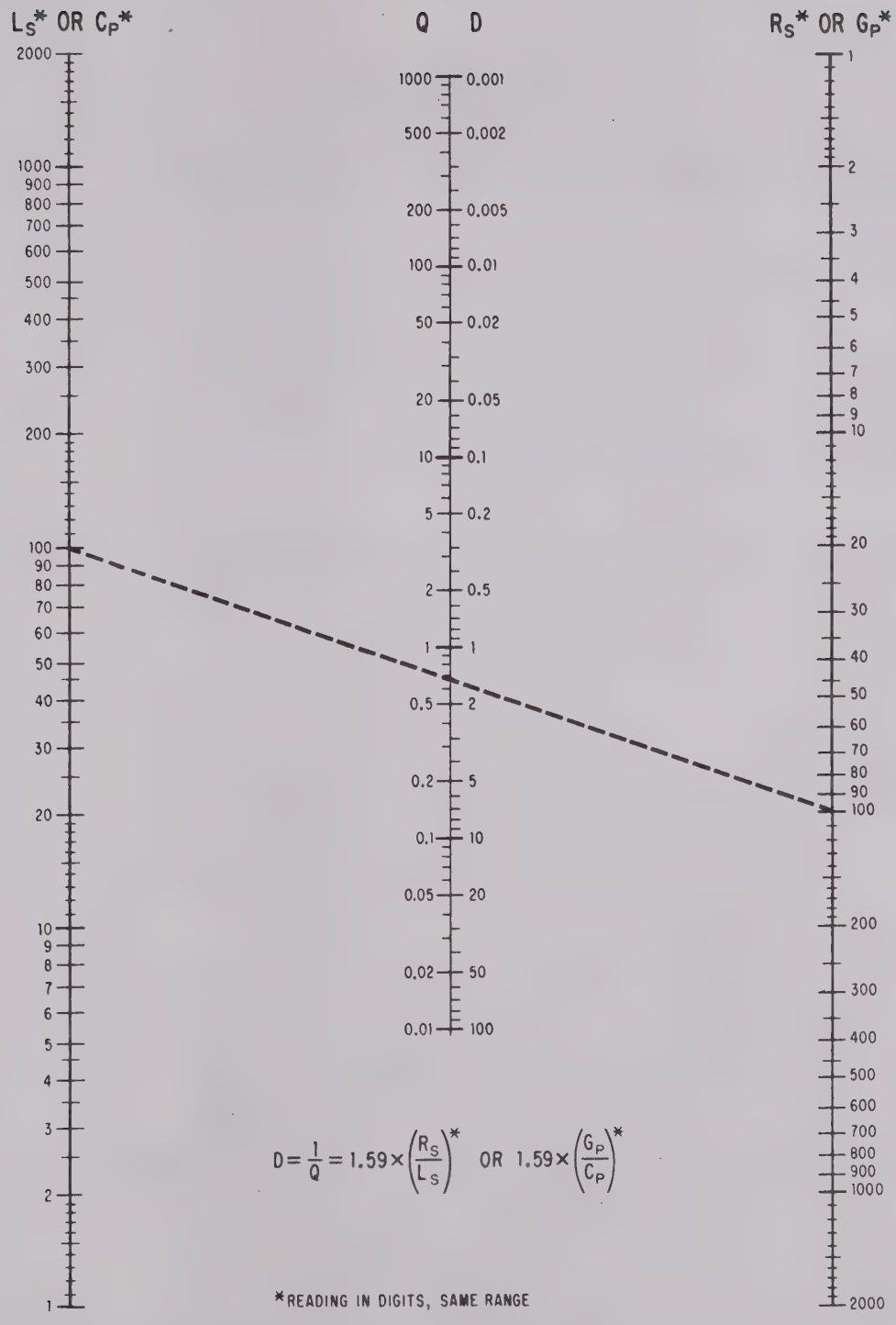



Figure 2-8. Model 252 D-Q Nomograph

## 2.3.6 Using the Bias Feature

**WARNING**

TO AVOID PERSONAL INJURY FROM ELECTRICAL SHOCK OBSERVE SAFETY PROCEDURES AS NEEDED FOR THE BIAS VOLTAGE APPLIED.

Bias voltage is necessary or desirable when measuring the capacitance of diodes or of some electrolytic or tantalum capacitors.

There is a provision on the rear panel for connecting an external bias source of zero to 5ØVDC. Remove the shorting link between BIAS terminals when using this feature.

If the external bias supply is not a low AC impedance type, it should have a capacitor bypass of five times the range full-scale value connected across the bias terminals. The bias supply should be current limited to Ø.1A maximum.

With no bias supply connected, the rear-panel + and - terminals must be strapped together.

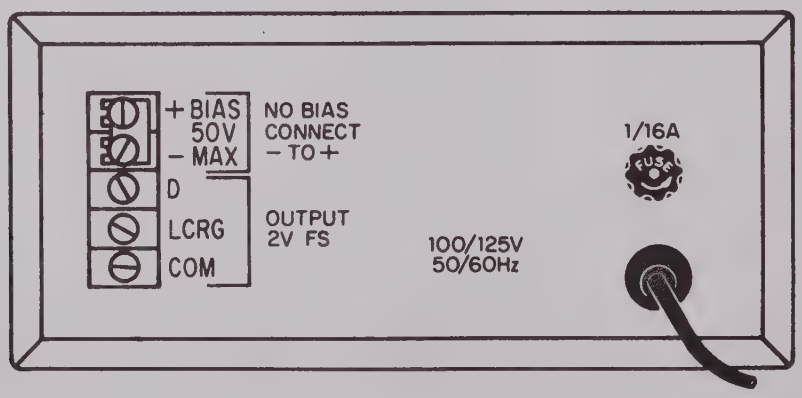



Figure 2-9. Rear Panel

### 2.3.7 Signal Output Terminals

Terminals are provided on the Model 252's rear panel for connecting external devices: digital voltmeters to increase full-scale resolution or simultaneous D reading; chart recorders to evaluate unknowns with changing impedances; limits comparators (ESI Model 1412B) for HI, LO, GO, and HI D component sorting.

The analog output signals are proportional to the function selected (L, C, R, or G) and D (for L and C only). Specifications for these signals are:

| | |
|---|---|
| Scale Factor | 1V per 1000 counts |
| Source Resistance | 1000Ω |
| Accuracy | ±(0.25% of reading + 1mV) |

### 2.3.8 Measuring Grounded Unknowns

The Model 252 is designed to measure ungrounded components. However, with a minor modification, it can be used to measure impedances that are connected directly or tightly coupled to earth ground.

**This first procedure outlines the modification of all instruments with serial numbers 928999 and smaller.**

1. Remove all instrument power.

2. Remove instrument cover by unscrewing the two cover screws and sliding the cover off.

**WARNING**

**TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.**

3. Locate the Power Supply Circuit Assembly, Part No. 53157. (Attached to the rear panel.)

4. Remove jumper wire W1 from this assembly (see Figure 2-10).

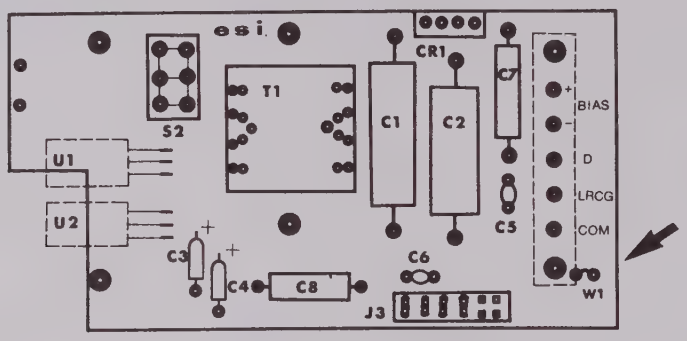



Figure 2-10. Power Supply Circuit Assembly

5. Locate the Range Switch on the front panel.

6. Unsolder and isolate the solder lug from the Range Switch making sure the black wire remains attached to the switch terminal (see Figure 2-11).

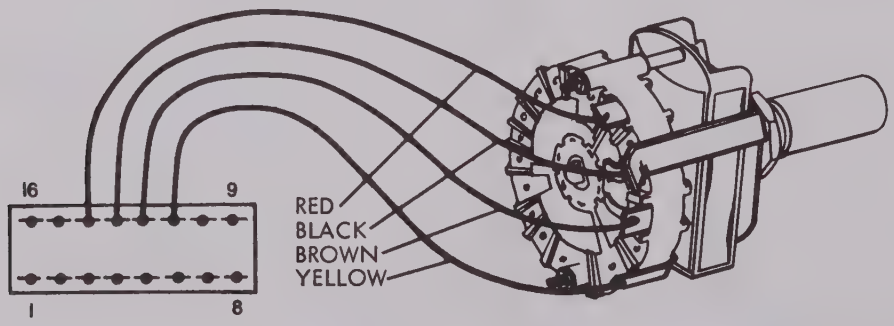



Figure 2-11.

7. Replace instrument cover.

The modification of instruments with Serial Numbers 929000 and greater is as follows:

1. Locate the connector strip on the rear panel (see Figure 2-12).

2. Remove and isolate the spade lug from the terminal marked COM.

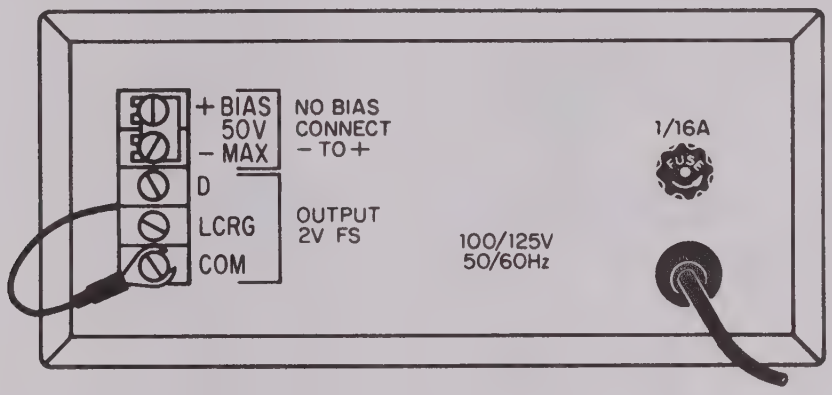



Figure 2-12.

To make measurements of grounded unknowns, connect the grounded side of the unknown to the KELVIN KLIPS® with the red insulating hinge-spool and the ungrounded end to the clip with the black spool (see Figure 2-13).

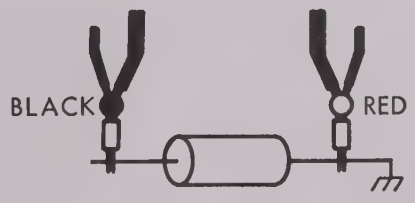



Figure 2-13.

A small zero offset may become apparent during low value grounded capacitance measurements. This offset can be corrected by making a reading with the unknown connected only to the red clips and subtracting it from the final measured capacitance.

To return to normal ungrounded measurements reverse the above procedures.

### 2.3.9 Measuring Battery Impedance

Current producing capabilities of a battery can be determined by using the 252 to measure its impedance. Series resistance and series capacitance measurements can be made on batteries with voltages up to 50V. To measure series resistance:

1. Set the 252 to measure Rs and to the highest measurement range.

2. Remove the shorting bar from the + and - bias terminals. The bias terminals are located on the instrument's rear panel terminal strip.

3. Connect a 500µF (or larger) capacitor, whose working voltage is greater than the rated voltage of the battery, to the bias terminals (see Figure 2-14). Observe correct polarity when connecting the capacitor.

4. Connect the test leads with the red hinge-spool to the positive battery terminal and the lead with the black hinge-spool to the negative terminal (see Figure 2-14).

5. Move the range switch to the range with the highest resolution displayed (see Section 2.2.5) unless that range uses excessive test current for the size of battery being measured. See Table 1-1 for range test currents.

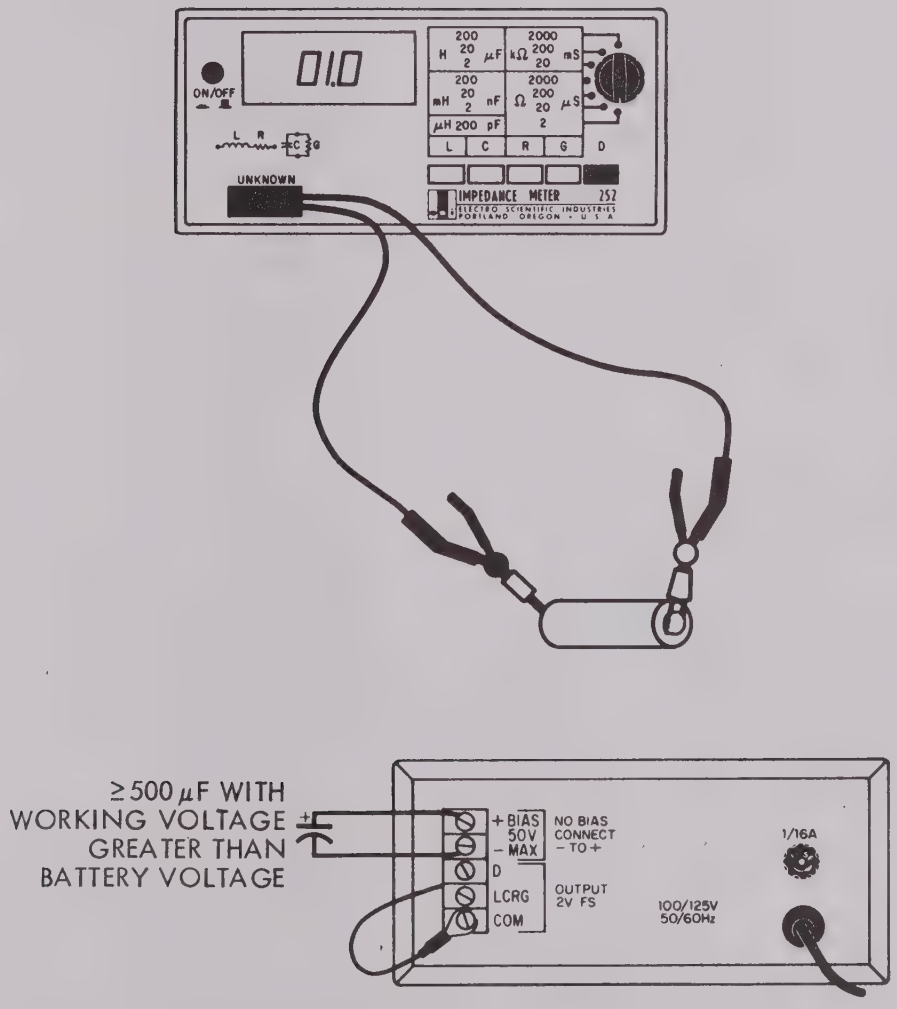



Figure 2-14. Measuring Battery Impedance

The Ls function must be used to measure the series capacitance of a battery. Instrument set up is the same as for Rs measurements (Figure 2-14). A negative reading will be shown, and the following equation must be used to convert the "-Ls" reading to "+Cs" values:

$$Cs = \frac{1}{(2\pi f)^2 \ (-Ls)}$$

Where: f = frequency in hertz
Cs = series capacitance in farads
Ls = series inductance in henrys

Care must be taken so the measurement current level of the 252's internal source does not exceed the rating of the battery being tested. See Table 1-1 for range test currents.

### 2.3.10 Component Sorting

Model 252, when used with ESI Model 1412B Limits Comparator, sorts components according to percent deviation and dissipation factor, simultaneously. Component sorting can be manual or automatic; Model 1412B provides four contact closures for operating automatic component handling equipment.

Model 1412B front panel controls set upper and lower limits around a nominal value (L, R, C, or G), with either of two full scale ranges -- 10% or 100%. An upper limit for dissipation factor (D) is also set by a front panel control. Test results are shown by four front panel LEDs. They indicate:

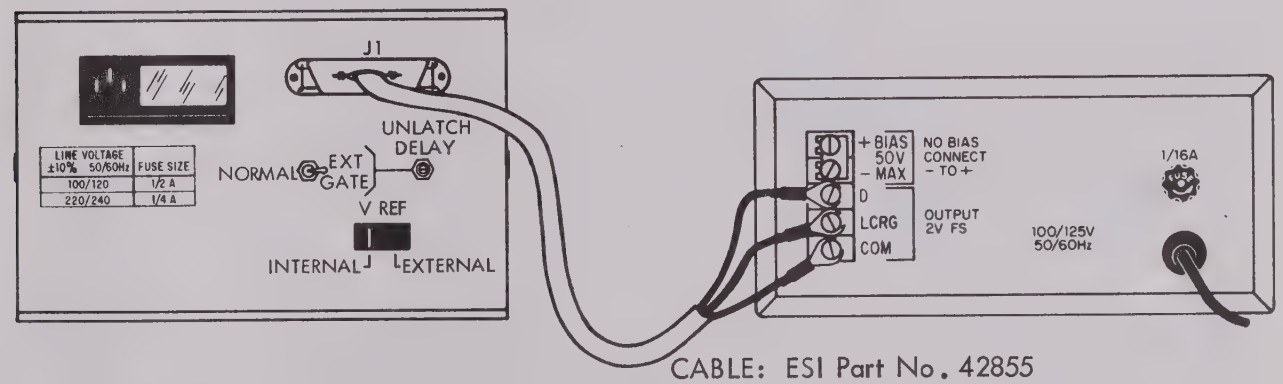
GO indicates value between - and + % limits and less than D limit.

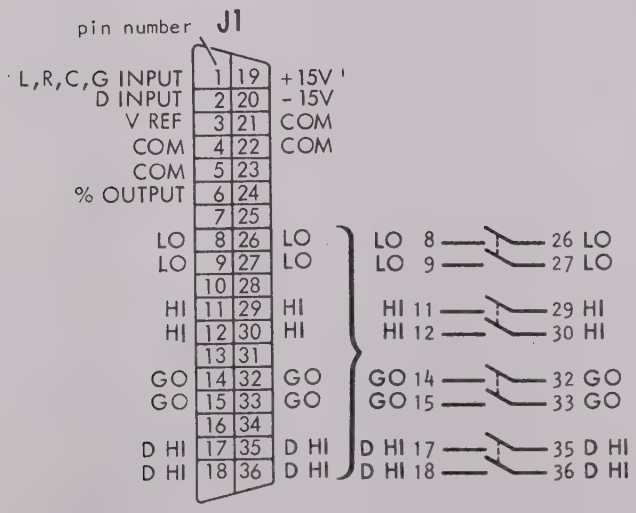
LO indicates value less than - % limit.

HI indicates value greater than + % limit.

D HI indicates dissipation factor greater than limit.

Connect the 252 and 1412B as shown in Figure 2-15.




NOTE: For resistive unknowns connect the D lead to the COM terminal

Figure 2-15. Model 252 and Model 1412B Interconnection

## Operation

The following instructions assume Model 252 and Model 1412B are connected and both are turned on.

Model 252 setup: (for capacitor sorting)

1. Push the C button on the Model 252 front panel.

2. Set the range switch to give maximum resolution on the display.

Model 1412B setup:

1. Set the rear panel V REF switch to INTERNAL.

2. Set NOMINAL VALUE switches to anticipated value.

3. Set LIMITS FULL SCALE toggle switches, and % LIMITS and D LIMIT dials to desired limits.

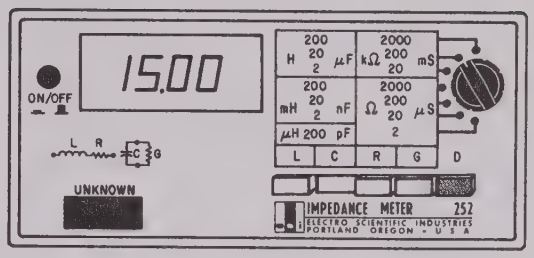
The measurement:

Connect unknown to the Model 252. If the unknown is within the set limits, the GO LED will light. If it is not within limits, the appropriate indicator will light.

Example: Sort 15µF capacitors within +25%, -15% limits with a maximum dissipation limit of Ø.Ø25Ø. Instrument set up is as follows:

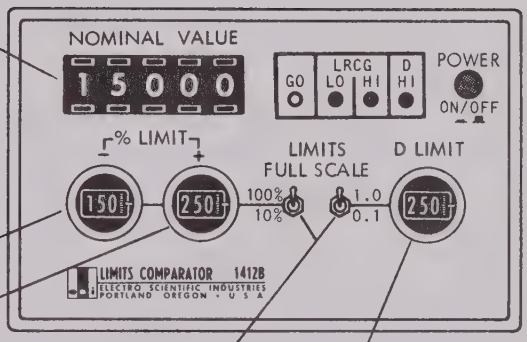
Model 252:

Function and Range settings




Model 1412B:

Nominal value setting




- % Limits setting

+ % Limits setting

LIMITS FULL SCALE Toggle switches settings

D Limit setting

Connect the unknown and observe indicator lights. If the LO LED is lit, the unknown is lower than the lower % limit. Similarly, if the HI LED is lit, the unknown is a larger value than the upper % limit. If the D HI LED is lit, the dissipation factor of the unknown exceeds the set limit. If the GO indicator is lit, the unknown value is within the desired limits; in the example, 15μF, +25%, -15%, with a dissipation factor less than Ø.Ø25Ø.

For further operating instructions, see the Model 1412B instruction manual.

# SECTION 3
# CIRCUIT DESCRIPTIONS

## 3.1 GENERAL DESCRIPTION

When measuring Cp or Gp, a voltage is applied across the unknown and range resistor in Figure 3-1. The voltage across the unknown is held constant to within one part in several thousand by the 1kHz oscillator feedback control circuit. A current proportional to the value of the unknown impedance is produced through the range resistor. The resultant voltage drop across the range resistor is separated into two vector components by the Phase Sensitive Detectors (PSD) and Reference Voltage Generator (RVG). Receiving gating signals from RVG, the PSD will measure Gp, the component in phase (0°) with RVG, and Cp, the component at quadrature (90°). The selected detector output is then fed to the A/D Converter which has a readout of 1000 counts/volt.

When measuring Ls or Rs, a voltage is applied across the unknown and range resistor in Figure 3-1. The voltage across the range resistor is held constant to within one part in several thousand by the 1kHz oscillator feedback control circuit. With a constant current flowing through the unknown, a voltage proportional to the value of the unknown impedance is developed across the unknown. The resultant voltage drop is separated into two vector components by the Phase Sensitive Detector (PSD) and Reference Voltage Generator (RVG). Receiving gating signals from the RVG, the PSD will measure Rs, the component in phase (0°) with the RVG, and Ls, the component at quadrature (90°). The selected detector output is then fed to the A/D Converter which has a readout of 1000 counts/volt.

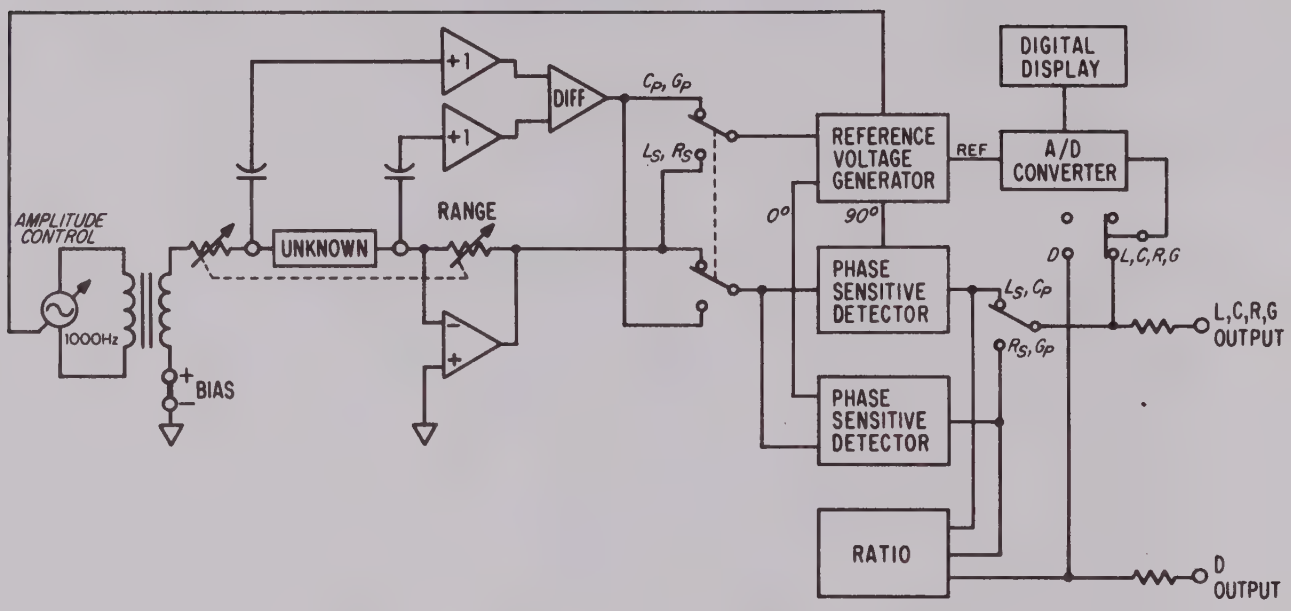



Figure 3-1. Model 252 Simplified Diagram

When measuring the dissipation factor (D) of inductors or capacitors, an analog ratio circuit is used. This circuit compares the loss component (Rs or Gp) to the reactive component (Ls or Cp) and presents a voltage proportional to D to the A/D Converter.

Analog output voltages are available at the rear of Model 252 for the selected function (L, C, R or G) and simultaneous D (for L or C unknowns).

## 3.2 DETAILED CIRCUIT DESCRIPTIONS

In the following descriptions several conventional resistor networks are involved. To identify which resistor elements are being discussed, the elements are identified by the lower terminal numbers and each is prefixed by a small letter "r". Example: U7 (r1 and r2).

### 3.2.1 1kHz Oscillator

The 1kHz signal applied to the unknown and range resistor is generated by a power op amp U1, used as a Wien bridge oscillator, with C20, C21 and U19 (r4 and r5) controlling the frequency. Amplitude control for the oscillator is provided by U27 working as a reference voltage null integrator and U35 as the feedback control element. Transformer T2 provides coupling to the unknown and range resistor with provision for inserting bias voltage at rear terminals.

### 3.2.2 Unknown Differential Amplifier

The voltage drop across the unknown is measured by differential amplifier U3-3. Amplifiers U1-3 and U1-4 act as high impedance AC-coupled buffers to prevent loading the unknown. Resistors U6 (r7 and r8) and U7 (r1 and r2) determine the gain (x1) of U3-3. Trimmer R6 is an adjustment for common-mode voltage rejection. Amplifiers U3-2 and U3-3 are switch (U5) selectable gain stages that provide an overall gain of x1, x10 or x100. Trimmers R11 through R17, switched by U4, provide phase adjustments for each range.

### 3.2.3 Range Amplifier

The voltage drop across the range resistor (R22, R24 through R27), selected by U12, is measured by amplifier U1-2. Relay K1 switches R22 in series with the unknown for ranges 20Ω and 2Ω (or equivalent). For these ranges U36 is used as a gain amplifier of x1 or x10. Other ranges use U36 as a guard amplifier to reduce the effect of shunt impedances on high value unknowns.

### 3.2.4 Reference Generator and Phase Sensitive Detector

#### Reference Generator

A DC voltage proportional to the voltage across the unknown or range resistor is generated by U13-2 and U13-3 used in an operational rectifier circuit. For reactive unknowns, amplifier U13-1 is used as the AC voltage reference input to the operational rectifier. Gating signals for the in-phase and quadrature phase sensitive detectors are produced by U15-3 and U15-4 used as zero crossing detectors. Trimmer R35 is used for adjustment of the 90° reference gate.

#### Phase Sensitive Detectors

Voltage across the unknown (Rs or Ls) or across the range resistor (Cp or Gp) is measured by two phase-sensitive detectors. The in-phase (0°) detector consists of amplifiers U17-1 and U30, together with resistor network U23 and switching gate U20. Ripple filtering is provided by R46, R47, C17, and C18. The quadrature (90°) detector consists of amplifiers U17-4 and U22, together with resistor network U21 and switching gate U20. Ripple filtering is provided by R41, R42, C13, C14, and C15. Trimmer R45 is used to adjust the full scale value of L or C.

### 3.2.5 Dissipation Factor Circuit

The dissipation factor (D) of inductors or capacitors is derived from the ratio of the loss component (0° phase detector) and reactive component (90° phase detector). This is done with a pulse-width modulator consisting of integrating amplifier U26 and resistor summing network using U28, R60 and R58. The ratio of R (or G) to L (or C) changes the pulse width ratio of the switching amplifier U27 (with switch U24) to produce a null at the integrator input. Comparator U15-2 acts as the switch driver and is frequency set by the test frequency of the instrument. Amplifiers U27-1 and U27-3 together with

switch U24 are the demodulator which produces an analog voltage proportional to the pulse width variation and scaled to equal the dissipation factor. Trimmer R52 adjusts full scale D value.

### 3.2.6 Overload Blanking Circuit

U15-1 is a comparator amplifier. It monitors the signal levels of the phase detector input and the level regulator amplifier U27-4. When either level exceeds its limit, comparator U15 goes low. This output is combined with a digital overrange signal at the input of a NAND gate of U29 to provide a display blanking output.

### 3.2.7 Analog to Digital Converter

The A/D converter resides in U31 (MC14433) which is a CMOS dual-slope integrating converter. This circuit provides a multiplexed output which is decoded and displayed by a plug-in circuit assembly (42916).

### 3.2.8 Function and Range Programming

A bipolar PROM (U33) stores the necessary range and function programming information for Model 252. The stored program has 32 addresses each with 8 bits of data. These addresses are reached by 2 function bits and 3 range bits which are set by the front panel switches.

# SECTION 4
# MAINTENANCE

**WARNING**

**TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.**

## 4.1 CALIBRATION PROCEDURE

Although Model 252 is inherently stable, good maintenance practices suggest it be calibrated every six months; more often if used in extreme environments or if inaccurate readings are suspected.

| Equipment Required | Minimum Specifications |
|---|---|
| Frequency Counter | Measure 1000Hz with resolution of 1Hz |
| Digital Voltmeter | Resolution of 100µVDC |
| Resistance Standard | 1000Ω ±0.05%, non-inductive such as ESI Model SR 1. |
| Capacitance Standard | 100nF, ±0.05%, silvered mica or polystyrene |
| Dissipation Factor Standards | 1µF Decade Capacitor, 5 dial, polystyrene, D<0.0002;<br>10µF polystyrene capacitor with D known to ±0.001;<br>100µF capacitor with D known to ±0.001 |
| KELVIN KLIPS® Four-Terminal Clips | ESI Part No. 43072 |

Refer to Figure 4-1 for adjustment locations.

### 4.1.1 Power Supply Check

Setup - Turn on instrument and allow ten minute warm-up period; then remove cover. Check - Power supply voltages at C44 and C45 should be + and -5V ±5% (4.75V to 5.25V). Use rear panel COM terminal for voltmeter low input.

### 4.1.2 Oscillator Adjust

Setup - Press R function button. Set RANGE switch to 2ØØØΩ and short unknown test leads together. Connect voltmeter high input to Test Socket (TS) pin (2) and frequency counter input to TS (1). Use rear panel COM terminal for circuit common. Adjustment - Set trimmer S for DVM reading of ØV (±Ø.2V). Counter reading should be 1ØØØHz (±1ØHz).

### 4.1.3 L, C, R, G Alignment

1. R, G PHASE DETECTOR ZERO TRIM. Setup - Press R function button and set RANGE switch to 2ØØØΩ and short unknown test leads together. Connect DVM input to TS (6). Adjustment - Set trimmer P for +Ø.3mV ±Ø.1mV on DVM.

2. UNKNOWN AMP COMMON MODE TRIM. Setup - Press R function button and set RANGE switch to 2Ω and short unknown test leads together (keep movable jaws adjacent). Adjustment - Adjust trimmer J for DVM reading of ØV ±Ø.3mV at TS (6).

3. L, C PHASE DETECTOR ZERO TRIM. Setup - Press L function button and set RANGE switch to 2ØØmH. Short unknown test leads together and connect DVM input to TS (5). Adjustment - Set trimmer M for +Ø.3mV ±Ø.1mV on DVM.

4. L, C, R, G OUTPUT AMP ZERO TRIM. Setup - Same as step 3 except connect DVM input to TS (4). Adjustment - Set trimmer V for ØV ±Ø.3mV on DVM.

5. UNKNOWN AND RANGE AMP PHASE TRIM. Setup - Press C function button and set RANGE switch to 2ØØnF. Connect decade capacitor to unknown test leads and set at 16ØnF (±5%). Adjustment - Note voltage at TS (6) and then push L function button, again noting TS (6) voltage. The two should be equal (±Ø.3mV). If not, adjust trimmer X until they are. Next adjust trimmer D for ØV ±Ø.3mV output at TS (6) for both L and C functions.

6. QUADRATURE GATE PHASE TRIM. Setup - Press R function button and set RANGE switch to 2ØØØΩ. Connect 1ØØØΩ (±Ø.Ø5%) standard to unknown test leads. Adjustment - Set trimmer L for DVM reading of ØV ±Ø.3mV at TS (5).

7. R, G FULL SCALE TRIM. Setup - Same as step 6. Adjustment - Set trimmer K for front panel digital reading of 1ØØØ. With DVM, read voltage at TS (4) and adjust trimmer R for +1.ØV (±Ø.5mV).

8. L, C FULL SCALE TRIM. Setup - Press C function button and set RANGE switch to 2ØØnF. Connect 1ØØnF (±Ø.Ø5%) standard to the unknown test leads. Adjustment - Set trimmer N for front panel reading of 1ØØØ.

### 4.1.4 Dissipation Factor (D) Alignment

1. LOW LEVEL ZERO TRIM. Setup - Press C function button and set RANGE switch to 2ØØnF. Connect a low loss (D<Ø.ØØØ2) decade capacitor to unknown test leads. Adjustment - Set the decade capacitor to 1Ø5nF and, with a DVM, note the voltage at TS (3) or D output terminal at the rear panel. Set the decade to 5nF and

again note the voltage. If the two voltages are not equal (±1mV), adjust trimmer W until switching between 105nF and 5nF produces equal readings.

2. HIGH LEVEL ZERO TRIM. Setup - Same as step 1. Adjustment - Set decade capacitor to 100nF and adjust trimmer U until voltage at TS (3) or D output is 0V ±0.3mV.

3. D FULL SCALE TRIM. Setup - Same as step 1. Adjustment - Set the decade capacitor for a front panel C reading of 159.2nF. Connect the 1000Ω standard resistor in parallel with the decade capacitor. Set trimmer T for a front panel D reading (push D button) of 1.000.

**NOTE:** The following trim adjustments set D=0 for all C ranges except 200nF, which was adjusted in step 5 of Paragraph 4.1.3.

4. 200pF RANGE D TRIM. Setup - Press C function button and set RANGE switch to 200pF. Connect the low loss (D<0.0002) decade capacitor to unknown test leads. Adjustment - Set the decade to 100pF (±20%) and adjust trimmer H for 0V ±0.3mV at TS (3), or D output.

5. 2nF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 2nF. Adjustment - Set decade to 1nF (±20%) and adjust trimmer F for 0V ±0.3mV at TS (3), or D output.

6. 20nF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 20nF. Adjustment - Set decade to 10nF (±20%) and adjust trimmer E for 0V ±0.3mV at TS (3), or D output.

7. 2μF RANGE D TRIM. Setup - Same as step 4, except set RANGE switch to 2μF. Adjustment - Set decade to 1μF (±20%) and adjust trimmer C for 0V ±0.3mV at TS (3), or D output.

8. 20µF RANGE D TRIM. Setup - Set RANGE switch to 20µF and connect a 10µF (±20%) capacitor (D known to ±0.001) to unknown test leads. Adjustment - Adjust trimmer B for front panel D reading (push D button) equal to D value of the 10µF capacitor.

9. 200µF RANGE D TRIM. Setup - Set RANGE switch to 200µF and connect a 100µF (±20%) capacitor (D known to ±0.001) to unknown test leads. Adjustment - Adjust trimmer A for front panel D reading (push D button) equal to D value of the 100µF capacitor.

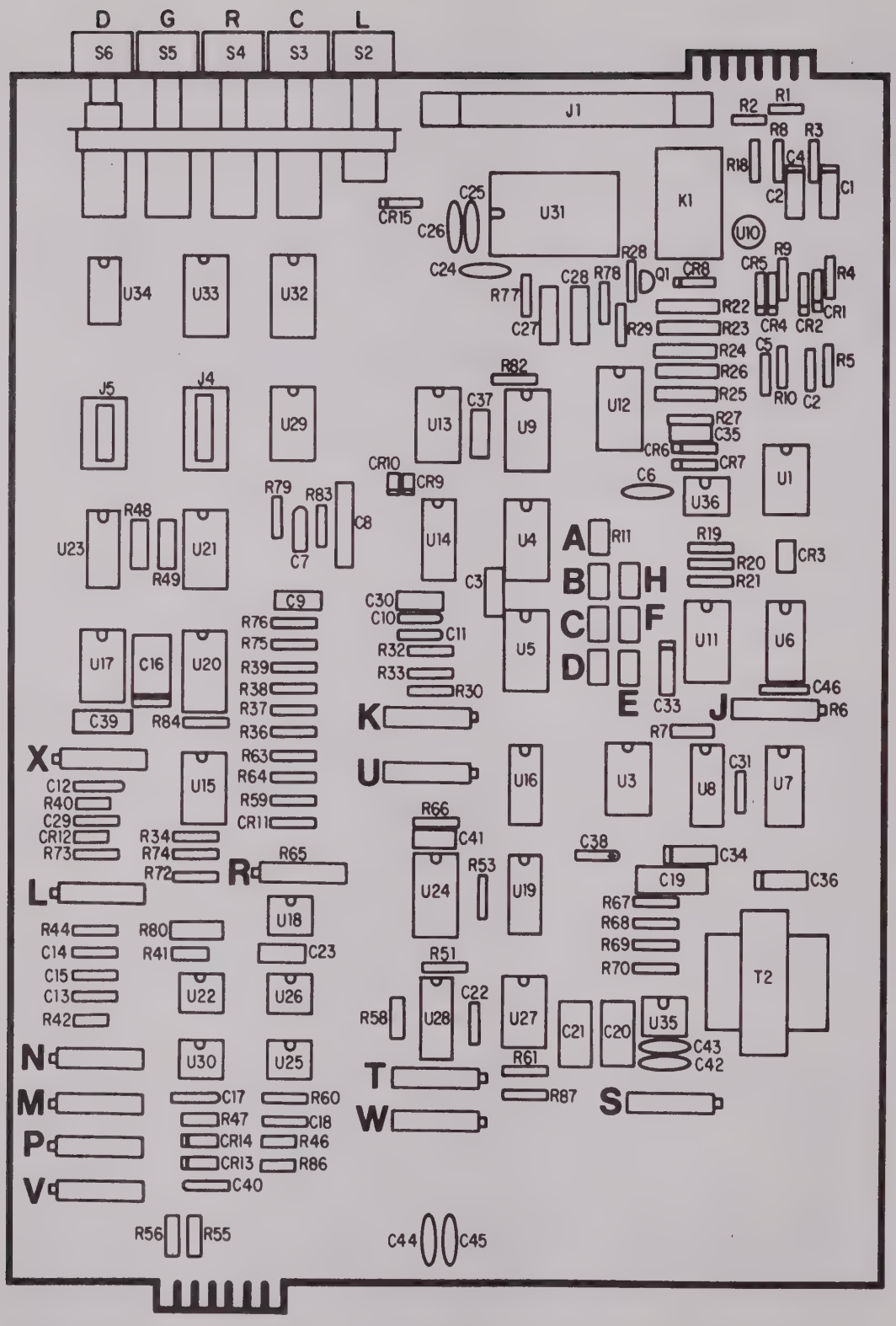

D
G
R
C
L
S6
S5
S4
S3
S2
J1
R2
R1
R8
R3
C4
C2
C1
R18
K1
U10
C25
C26
U31
CR15
C24
R28
Q1
CR8
R78
C28
R77
C27
R29
R22
R23
R24
R26
R25
CR5
R9
R4
CR4
CR2
CR1
C5
R10
C2
R5
U34
U33
U32
J5
J4
U29
R82
U13
C37
U9
U12
R27
C35
CR6
CR7
U1
CR10
CR9
C6
U36
R79
R83
C8
C7
R48
U23
R49
U21
U14
U4
A
R11
R19
R20
R21
CR3
B
H
C3
C30
C10
C11
R32
R33
R30
U5
C
F
D
E
C33
U11
U6
C46
J
R6
C9
R76
R75
R39
R38
R37
R36
U17
C16
U20
C39
R84
K
R7
X
U
U16
U3
U8
C31
U7
U15
C12
R40
C29
CR12
R73
R34
R74
R72
R66
C41
R65
R
C38
C34
C19
C36
R53
U24
U19
R67
R68
R69
R70
L
U18
R44
R80
C14
R41
C23
R51
T2
C15
C13
R42
U22
U26
R58
U28
C22
U27
C21
C20
U35
C43
C42
N
U30
U25
R61
T
M
C17
R60
R47
C18
R87
S
P
CR14
R46
W
CR13
R86
V
C40
R56
R55
C44
C45

Figure 4-1.

## 4.2 MAINTENANCE

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, and troubleshooting of the Model 252.

### 4.2.1 Preventive Maintenance

**WARNING**

REMOVAL OF INSTRUMENT COVERS MAY CONSTITUTE AN ELECTRICAL HAZARD AND SHOULD BE ACCOMPLISHED BY QUALIFIED SERVICE PERSONNEL ONLY.

Preventive maintenance performed on a regular basis will improve the reliability of this instrument. It may include cleaning, visual inspection, or even monitoring the operating environment.

#### 4.2.1.1 Cleaning

**CAUTION**

AVOID THE USE OF CHEMICAL CLEANING AGENTS WHICH MIGHT DAMAGE THE PLASTICS USED IN THIS UNIT. DO NOT APPLY ANY SOLVENT CONTAINING KETONES, ESTERS OR HALOGENATED HYDROCARBONS. TO CLEAN, USE ONLY WATER SOLUBLE DETERGENTS, ETHYL, METHYL, OR ISOPROPYL ALCOHOL.

**Exterior.** Loose dust may be removed with a soft cloth or a dry brush. Water and mild detergent may be used; however, abrasive cleaners should not be used.

**Interior.** Use low-velocity compressed air to blow off the accumulated dust. Hardened dirt can be removed with a cotton-tipped swab, soft, dry cloth, or a cloth dampened with a mild detergent and water.

#### 4.2.1.2 Visual Inspection

This instrument should be inspected occasionally for such defects as broken connections, improperly seated semiconductors, damaged circuit boards, and heat-damaged parts.

The corrective procedure for most visible defects is obvious. If heat damaged components are found, particular care must be taken. Overheating usually indicates other trouble may be present in the instrument. It is important that the cause of overheating be corrected to prevent recurrence of the damage.

### 4.2.2 Troubleshooting

The following troubleshooting information is provided to augment other sections of this manual. The Circuit Description and Part Lists and Schematic Diagrams sections should be used to full advantage. Section 3 in this manual gives circuit description information while, Section 5 contains the part lists and schematic diagrams.

#### 4.2.2.1 Troubleshooting Aids

**Schematic Diagrams.** Schematic diagrams are provided on foldout pages in Section 5. The electrical value and circuit numbers of each component are shown on the diagrams. Power supply voltages are also shown.

**Circuit-Board Illustrations.** Illustrations of circuit boards are shown along with the schematic diagrams. Each board-mounted electrical component is identified by its circuit number.

**Test Point Locations.** Test point locations have been indicated on both the schematic diagrams and the circuit-board illustrations.

**Component Color Code.** Colored stripes or dots on resistors and capacitors signify electrical values, tolerances, etc., according to the EIA standard color code. Components not color-coded usually have the value printed on the body.

**Multi-pin Connector Identification.** Multi-pin connectors are soldered to the circuit boards. They mate with ribbon type cable assemblies to carry signals between boards. Connector pin 1 is indexed with a number 1 etched on the circuit board. Each connector is identified by a P number and can be located by using the circuit board illustration in Section 5 of this manual. P numbers shown on the illustration correspond to the P numbers on the schematic diagrams.

### 4.2.2.2 Troubleshooting Procedure

This troubleshooting procedure checks the simple trouble sources before proceeding with more extensive troubleshooting. The first few checks ensure proper connection and operation. If the trouble is not located by these checks, the remaining steps aid in locating the component. When the defective component is located, it should be replaced using the information given under Corrective Maintenance.

1. **Check Instrument Set Up.** Make sure the instrument is properly plugged into a wall socket. Also, check the rear panel line voltage switch and the line fuse to see that they match the line voltage being used.

2. **Visual Check.** Visually check the portion of the instrument in which the trouble is suspected. Many problems can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, or components bent over and touching.

3. **Check Voltages.** A circuit stage may not be operating due to incorrect supply voltages. Typical supply voltages are given on

the diagrams; however, these are not absolute and may vary slightly between instruments.

4. **Trace the Signal.** The analog portion of the circuitry can be checked by tracing the signal with an oscilloscope. By noting where the signal disappears or distorts, the source of trouble can be located.

5. **Check Individual Components.** The following methods are provided for checking the individual components. Components which are soldered in place can sometimes be checked by disconnecting one end to isolate the measurement from the effects of surrounding circuitry.

   a. **TRANSISTORS.** It is always best to check transistor operation under operating conditions. Transistors that are soldered to the circuit board should first be checked in-circuit using a dynamic transistor testor; then a replacement can be substituted to verify that the old transistor is bad. Socketed transistors can be checked by substituting a component known to be good; however, be sure that circuit conditions are not such that a replacement might also be damaged. If substitute transistors are not available, check the old transistor out-of-circuit using a dynamic tester. Be sure the power is off before attempting to remove or replace any transistor.

   b. **INTEGRATED CIRCUITS.** Analog IC's such as comparators and operational amplifiers can usually be checked in-circuit with a voltmeter or test oscilloscope. An understanding of the device and circuit operation is essential for this type of troubleshooting. (For example, an op amp can be tested by measuring the input and output circuit voltages and comparing this ratio to the ratio of input and feedback resistors.)

      Analog IC's that are socketed can also be checked out-of-circuit using a dynamic tester such as the ESI Model 1234.

Digital IC's are best checked in-circuit using a logic probe or voltmeter. Use care when checking voltages and waveforms around DIP (Dual-Inline-Package) IC's so that adjacent leads are not shorted together. A convenient means of connecting a test probe to 14 and 16 pin IC's is with an IC test clip. This device also doubles as an extraction tool.

c. **DIODES.** A diode can be checked for an open or shorted condition by measuring the resistance between terminals with an ohmmeter set to the R X 1k scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed.

**DO NOT USE AN OHMMETER SCALE THAT HAS A HIGH INTERNAL CURRENT. HIGH CURRENTS MAY DAMAGE THE DIODES UNDER TEST.**

d. **RESISTORS.** Check resistors with an ohmmeter. Resistor tolerance is given in the Parts List. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

e. **CAPACITORS.** A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter on the highest scale. Use an ohmmeter that will not exceed the voltage rating of the capacitor. (Be careful to observe correct polarity when checking electrolytic capacitors.) The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter, or by checking whether the capacitance passes AC signals.

## 4.3 CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair.

### 4.3.1 Obtaining Replacement Parts

**Standard Parts.** All electrical and mechanical replacement parts for the Model 252 can be obtained from Electro Scientific Industries, Inc. However, many of the electronic components can be obtained locally in less time than is required to order them from ESI. Before purchasing or ordering replacement parts, check the parts list for value, tolerance rating, and description.

> **NOTE:** When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect the performance of the instrument. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Order all special parts directly from Electro Scientific Industries.

### 4.3.2 Component Replacement

**WARNING**

DISCONNECT ALL POWER TO THE INSTRUMENT BEFORE REPLACING COMPONENTS. FAILURE TO DO SO MAY RESULT IN ELECTRICAL SHOCK.

**Semiconductor Replacement.** Replacement semiconductors should be of the original type or a direct replacement. If the replacement semiconductor is not of the original type, check the manufacturer's basing diagram for proper lead identification.

Free Standing Components. When replacing any components that are free-standing (not directly mounted to circuit boards), be sure to place the new components in the same physical location and position as the old components. If this is not done, there may be a possibility of components touching and causing a short circuit.

## 4.4 REPACKAGING FOR SHIPMENT

If the Model 252 is to be shipped back to ESI for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted, complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions of not less than six inches more than the instrument dimensions; this will allow for cushioning.

2. Surround the unit with polyethylene sheeting to protect the finish of the instrument.

3. Cushion the instrument on all sides by tightly packing dunnage of urethane foam between the carton and the instrument allowing three inches on all sides.

4. Seal the carton with shipping tape or an industrial stapler.

# SECTION 5

# PARTS LISTS AND DIAGRAMS

## 5.1 MAINFRAME PARTS (Part No. 30252)

| DESCRIPTION | ESI PART NO. | SEE FIGURE NO. |
|---|---|---|
| Assemby, Back Panel (includes | 43157 | 5-4 |
| Circuit Assembly, Power Supply) | (42903) | (5-5) |
| Assembly, Cable, KELVIN KLIPS® | 43072 | |
| Assembly, Range Switch | 43151 | |
| P1 Header, 16 Pin, DIP | 20799 | |
| S1 Switch, Range | 43654 | |
| Circuit Assembly, Display | 42916 | 5-3 |
| Circuit Assembly, Motherboard | 43064 | 5-1,5-2 |
| Cover, Chasis | 42988 | |
| Display Window, Acrylic | 43116 | |
| Foot, Rubber | 08739 | |
| Frame, Front Panel | 43068 | |
| Front Panel Overlay | 42961 | |
| Handle, Kit | 43088 | |
| Instruction Manual | 43158 | |
| Knob, Range Switch | 22593 | |
| Pushrod, Power Switch | 43143 | |

Options:

| | |
|---|---|
| Front Panel Dust Cover | 43374 |
| Sorting Fixture | Model 2001 |
| Sorting Fixture Cable Assembly (4 BNC) | 43586 |

## 5.2 MOTHERBOARD CIRCUIT ASSEMBLY (Part No. 43064)

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| C1, C4 | Capacitor, 0.047µF, 200V, Mylar | 12239 |
| C2, C5, C13 C17, C18, C22, C29 | Capacitor, 1µF, 35V, Tant | 06472 |
| C3, C37, C39 | Capacitor, 1000pF, 500V, Poly | 07094 |
| C6 | Capacitor, 3.3pF, 1kV, Disc | 01925 |
| C7, C12 | Capacitor, 6.8µF, 35V, Tant | 25339 |
| C8 | Capacitor, 2000pF, 500V Mica | 02158 |
| C9, C19, C23, C27, C28 | Capacitor, 0.1µF, 200V, Mylar | 12121 |
| C10, C11, C14, C15, C31, C38, C40 | Capacitor, 2.2µF, 20V, Tant | 13283 |
| C16 | Capacitor, 0.33µF, 200V, Mylar | 12446 |
| C20, C21 | Capacitor, 0.0159µF, 1%, 100V | 18845 |
| C24-C26, C42-C45 | Capacitor, 0.05µF, 50V, Disc | 12116 |
| C30 | Capacitor, 390pF, 600V, Poly | 29299 |
| C33 | Capacitor, 0.01µF, 100V, Mylar | 12260 |
| C34 | Capacitor, 0.0033µF, 100V, Mylar | 20879 |
| C35 | Capacitor, 91pF, 2%, 600V Silver Mica | 43738 |
| C36 | Capacitor, 0.0022µF, 100V, Mylar | 12399 |
| C41 | Capacitor, 220pF, 600V, Poly | 29297 |
| C46 | Capacitor, 560pF, 600V, Poly | 25922 |
| CR1, CR2, CR4, CR5 CR9-CR12, CR15 | Diode, 1N914A | 12356 |
| CR3 | Diode Bridge, Mini DIP | 26339 |
| CR6-CR8 | Diode, 1N4005 | 01779 |
| CR13, CR14 | Diode, 1N4732, Zener | 12449 |
| J1 | Connector, 24 pin, PC | 43081 |
| K1 | Relay, 12V, 4PDT, PC MT | 43083 |
| Q1 | Transistor, 2N3702 | 12041 |
| R1-R3, R8, R29, R32, R41, R46, R56, R87 | Resistor, 1kΩ, 10%, 1/4W | 13920 |
| R4, R5, R9, R10 R18, R68, R70 | Resistor, 100kΩ, 10%, 1/4W | 13945 |
| R6 | Resistor, Trimmer, 200Ω, 15 Turn | 12083 |
| R7 | Resistor, 30.1kΩ, 1%, 1/8W | 43082 |
| R11-R17 | Resistor, Trimmer, 100kΩ, 1 Turn | 43092 |
| R19 | Resistor, 18kΩ, 10%, 1/4W | 13936 |
| R20, R28 | Resistor, 2.2kΩ, 10%, 1/4W | 13924 |
| R21 | Resistor, 220Ω, 10%, 1/4W | 13911 |
| R22 | Resistor, 1.001Ω, ESI, QB, 4T | 43302 |
| R23, R25 | Resistor, 1kΩ, ESI, QB | 24940 |
| R24 | Resistor, 100Ω, 0.02%, ESI, QB | 24939 |
| R26 | Resistor, 10kΩ, ESI, QB | 24941 |
| R27 | Resistor, 100kΩ, 0.1%, MF | 43300 |
| R30 | Resistor, 1.8kΩ, 10%, 1/4W | 13923 |

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| R31, R35, R65 | Resistor, Trimmer, 1kΩ, 15 Turn | 18469 |
| R33 | Resistor, 33Ω, 10%, 1/4W | 43301 |
| R34 | Resistor, 3.32kΩ, 1%, 1/8W | 21771 |
| R36-R40, R79 | Resistor, 10kΩ, 10%, 1/4W | 13933 |
| R42, R47 | Resistor, 68Ω, 10%, 1/4W | 13902 |
| R43, R45, R50, R85 | Resistor, Trimmer, 10kΩ, 15 Turn | 20145 |
| R44 | Resistor, 11kΩ, 1%, 1/4W | 13359 |
| R48, R49 | Resistor, 90.9kΩ, 1%, 1/4W | 24557 |
| R51, R58 | Resistor, 100kΩ, 1%, 1/4W | 21750 |
| R52 | Resistor, Trimmer, 2kΩ, 15 Turn | 12084 |
| R53 | Resistor, 2.2MΩ, 10%, 1/4W | 13962 |
| R54, R62 | Resistor, Trimmer, 100kΩ, 15 Turn | 21455 |
| R55, R86 | Resistor, 470Ω, 10%, 1/4W | 13915 |
| R57 | Resistor, Trimmer, 20kΩ, 15 Turn | 21199 |
| R59, R75, R76 | Resistor, 22kΩ, 10%, 1/4W | 13937 |
| R60, R84 | Resistor, 4.99kΩ, 1%, 1/4W | 21737 |
| R61, R77 | Resistor, 470kΩ, 10%, 1/4W | 13955 |
| R63, R64 | Resistor, 4.7kΩ, 10%, 1/4W | 13927 |
| R66, R80 | Resistor, 2kΩ, 1%, 1/4W | 21733 |
| R67 | Resistor, 82kΩ, 10%, 1/4W | 24812 |
| R69 | Resistor, 100Ω, 10%, 1/4W | 13907 |
| R71 | Resistor, Trimmer, 500Ω, 15 Turn | 12093 |
| R72 | Resistor, 20kΩ, 1%, 1/4W | 21743 |
| R73 | Resistor, 31.6kΩ, 1%, 1/4W | 21745 |
| R74 | Resistor, 63.4kΩ, 1%, 1/4W | 21748 |
| R78 | Resistor, 316kΩ, 1%, 1/4W | 21755 |
| R82 | Resistor, 10kΩ, 1%, 1/8W, MF | 21740 |
| R83 | Resistor, 402kΩ, 1%, 1/8W, MF | 21756 |
| S2-S6 | Switch, 5 Station, Pushbutton | 42882 |
| T2 | Transformer, Coupling | 42964 |
| U1, U3, U13, U17 | IC, 3403 | 40840 |
| U2 | IC, 759 | 43098 |
| U4 | IC, 4051 | 40841 |
| U5, U9, U20, U24 | IC, 4053 | 20744 |
| U6, U8 | Resistor Network, 1kΩ, 0.5%, 8 Resistors | 43117 |
| U7, U14, U16, U19, U21, U23, U28 | Resistor Network, 10kΩ, 0.5%, 8 Resistors | 43077 |
| U10 | LED Isolator, CLM 6000 | 25940 |
| U11, U12 | IC, 4052 | 20743 |
| U15 | IC, 339 | 40849 |
| U18 | IC, Precision 2.5V REF, 1403 | 43099 |
| U22, U30 | IC, 741 | 20668 |
| U25, U36 | IC, 356H | 41473 |
| U26 | IC, 741K | 21625 |
| U27 | IC, TL074 | 43299 |
| U29 | IC, 4012 | 43086 |
| U31 | IC, 14433 | 43067 |

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| U32 | IC, 4049 | 41305 |
| U33 | IC, 6331N | 43104 |
| U34 | Resistor Network, 22kΩ, 13 Res | 20712 |
| U35 | IC, 3080 | 20723 |
| | PC Board, Motherboard | 43063 |
| | Socket, 8 Pin, DIP for U18, U22, U25, U26, U30, U35 and U36 | 22410 |
| | Socket, 14 Pin, DIP for J5, U1, U3, U13, U15, U17, U27 and U29 | 19189 |
| | Socket, 16 Pin, DIP for J4,U4,U5, U9,U11,U12,U20,U24,U32 and U33 | 20860 |
| | Socket, 24 Pin, DIP for U31 | 41492 |

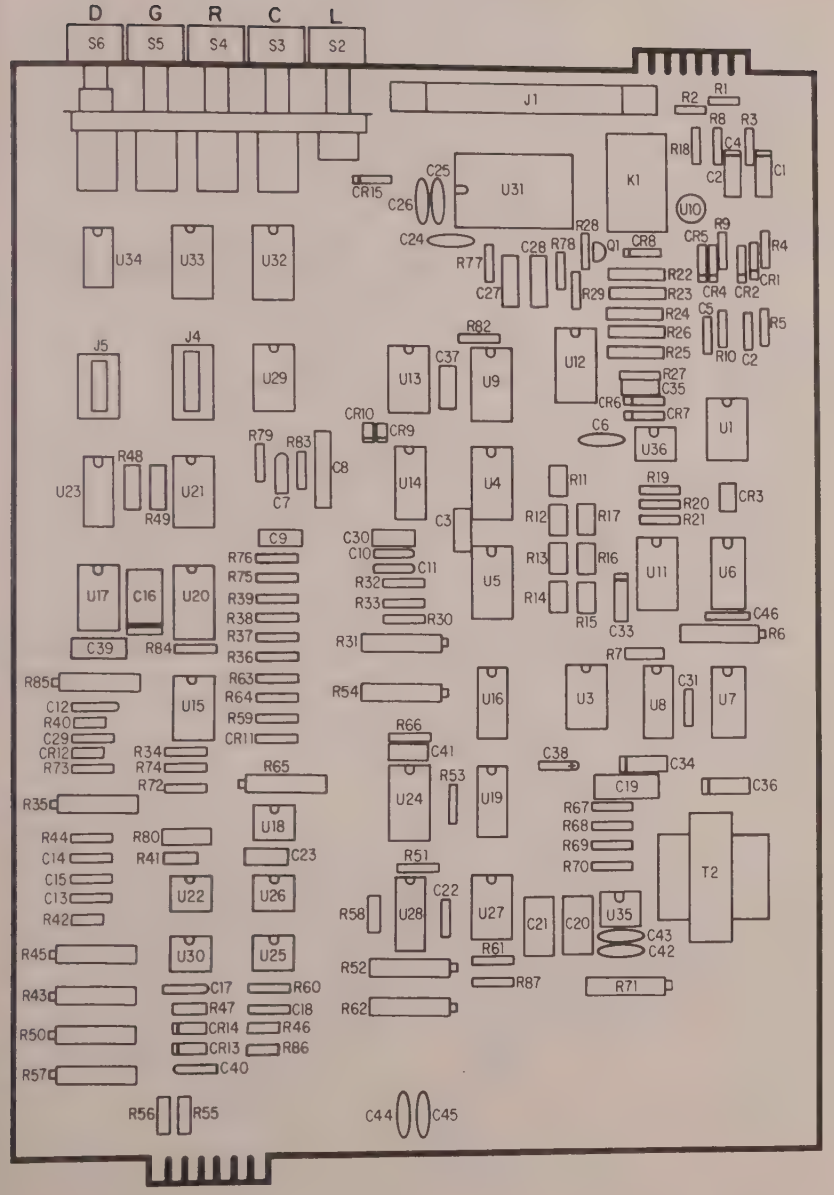
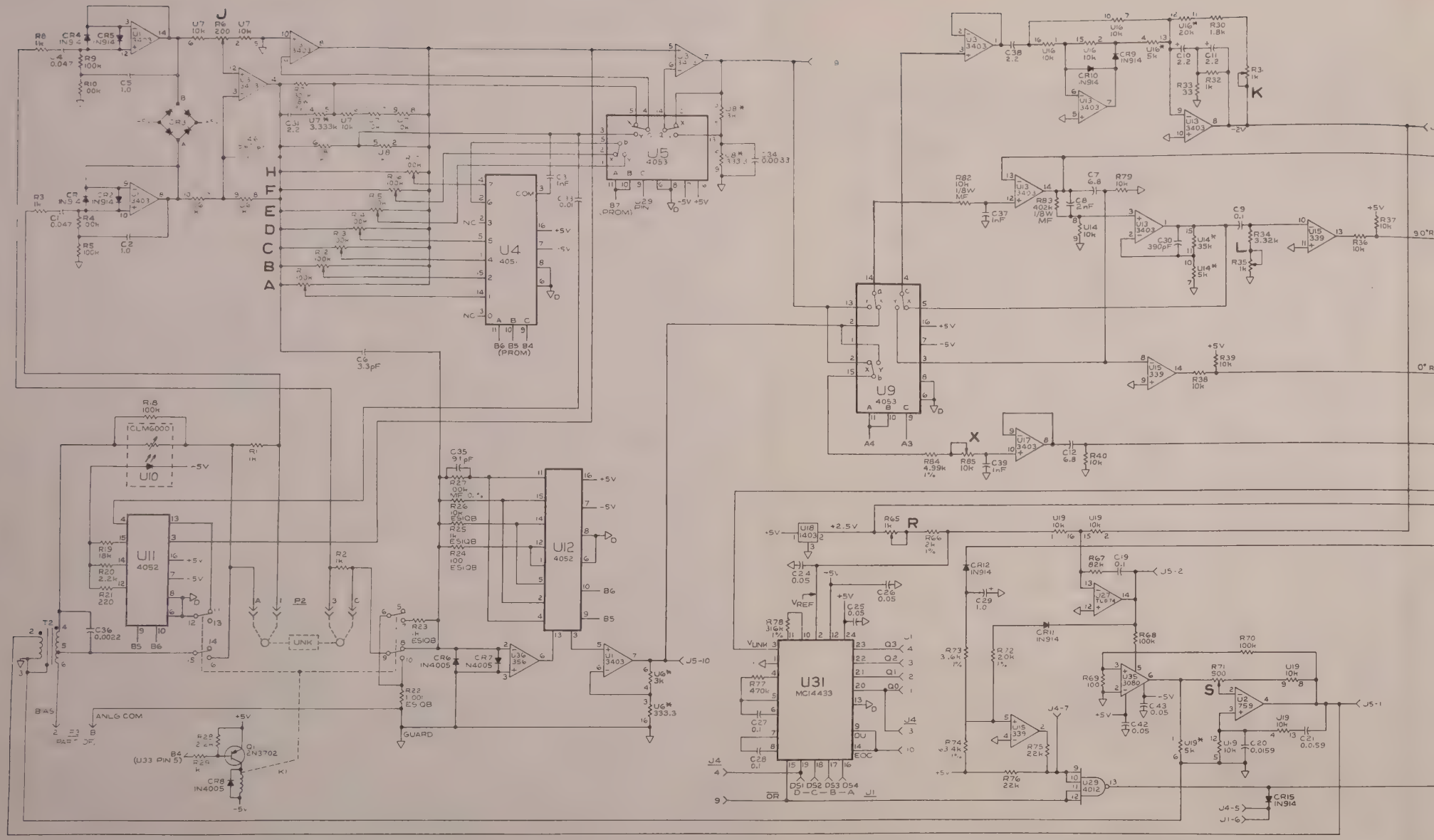


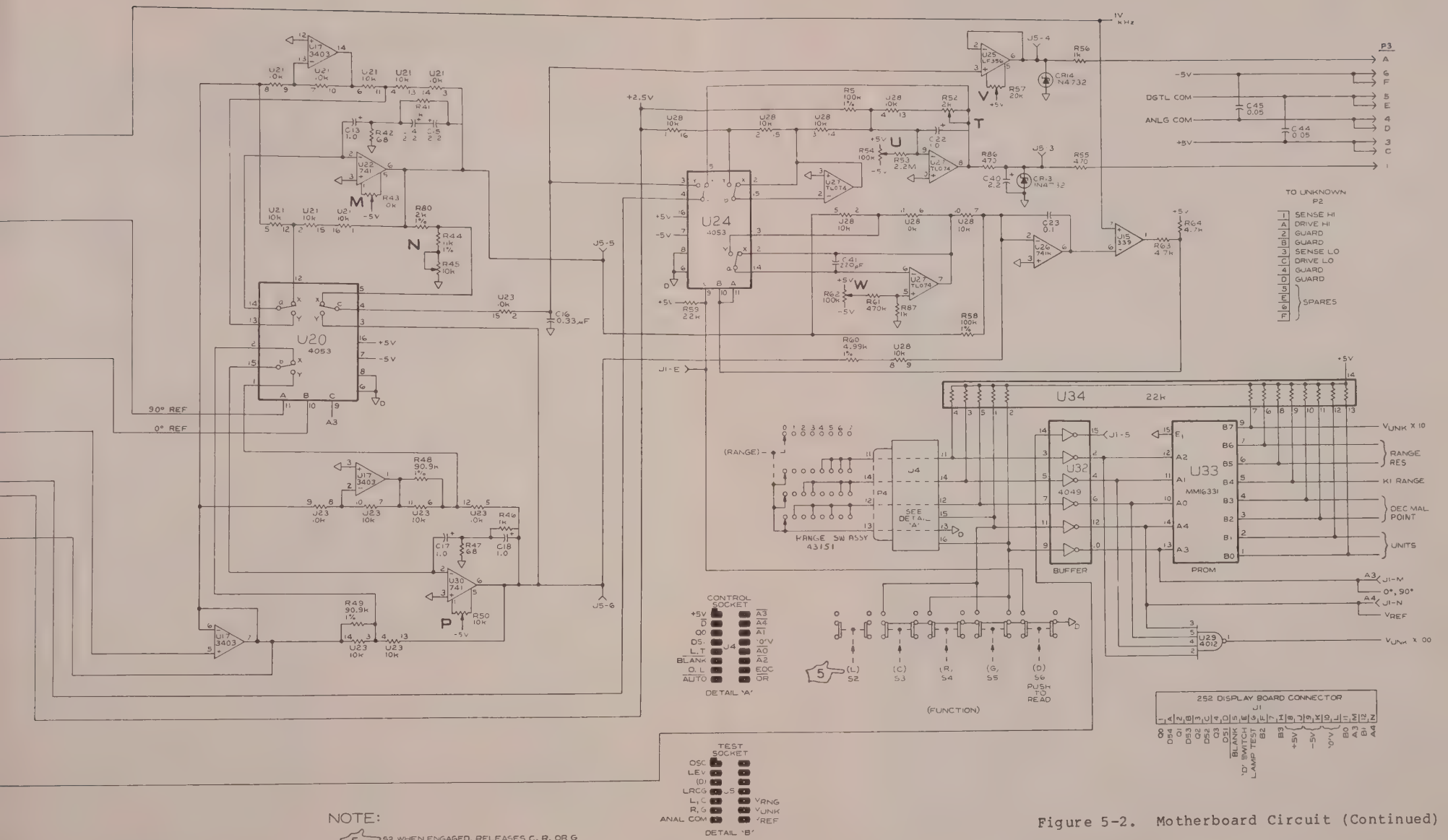

Figure 5-1. Motherboard



NOTE:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.
3. LARGE BOLD ALPHABET LETTERS DESIGNATED ON PC BOARD FOR TRIMPOT REFERENCE.
4. ASTERISK (*) DENOTES EQUIVALENT RESISTANCE VALUES FROM SERIES OR PARALLEL COMBINATIONS WITHIN THE RESISTANCE NETWORK PACKAGES.

Figure 5-2. Motherboard Circuit




NOTE:

5 S2 WHEN ENGAGED, RELEASES C, R, OR G FUNCTIONS (S3, S4 & S5).

Figure 5-2. Motherboard Circuit (Continued)

## 5.3 DISPLAY CIRCUIT ASSEMBLY (Part No. 42916)

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| CR1 | Diode, IN914A | 12356 |
| Q1-Q4 | Transistor, 2N3702 | 12041 |
| Q5 | Transistor, 2N3704 | 12077 |
| R1-R4 | Resistor, 1kΩ, 10%, 1/4W | 13920 |
| R5 | Resistor, 22kΩ,10%, 1/4W | 13937 |
| R6 | Resistor,220Ω, 10%, 1/4W | 13911 |
| R7 | Resistor, 100Ω, 10%, 1/4W | 13907 |
| R8,R10 | Resistor, 4.7kΩ, 10%, 1/4W | 13927 |
| R9 | Resistor, 150Ω, 10%, 1/4W | 13909 |
| U1 | IC, 4049 | 41305 |
| U2-U4 | IC, 4610, 7 Segment Display LED | 41350 |
| U5 | IC, 4630, ±1 Display LED | 41349 |
| U6 | IC, 4052 | 20743 |
| U7 | IC, 74LS47 | 43078 |
| U8 | Resistor Network, 150Ω | 43080 |
| | PC Board, Display | 42915 |

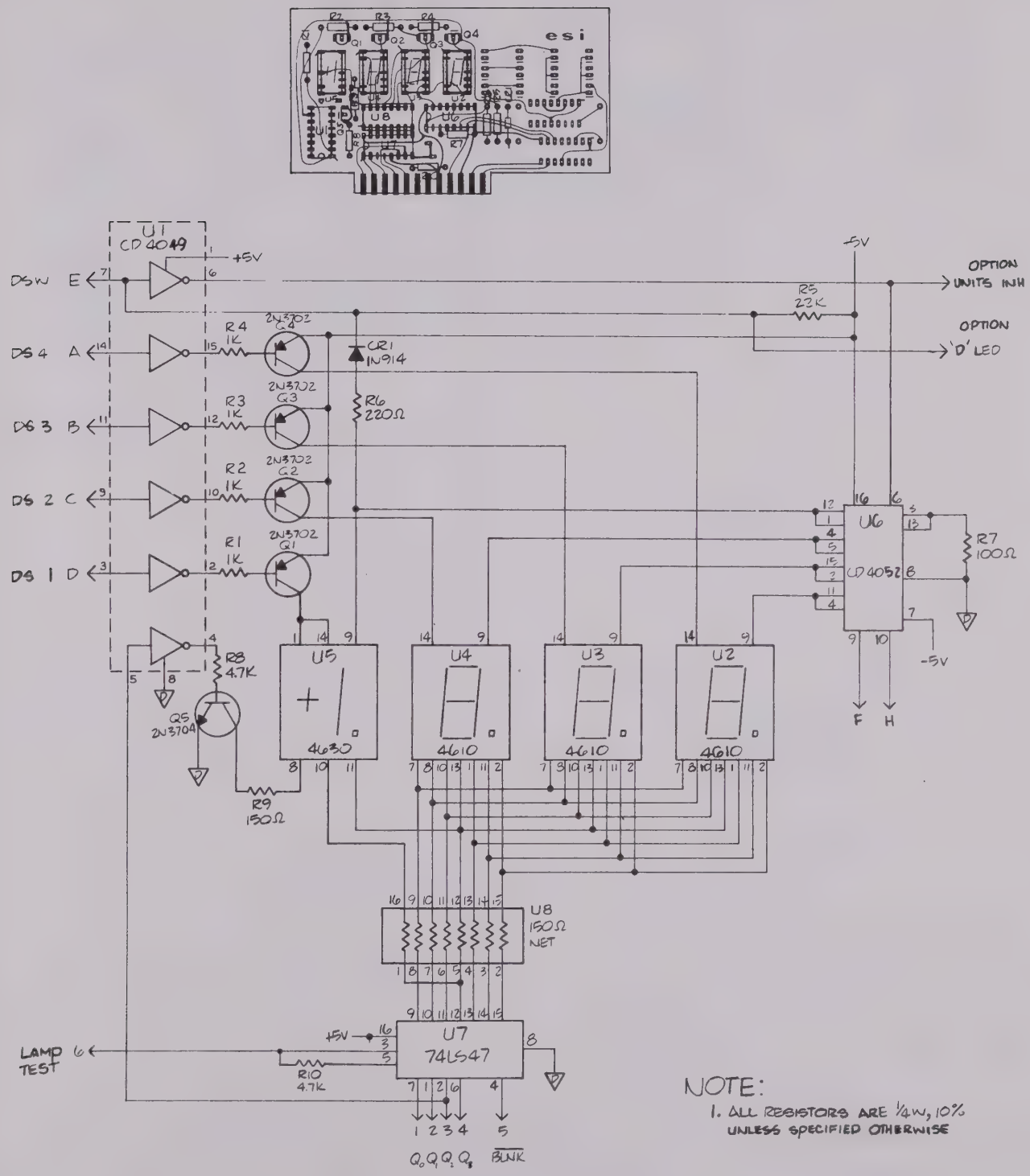



Figure 5-3. Display Circuit Assembly

## 5.4 BACK PANEL ASSEMBLY (Part No. 43157)

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| F1 | Fuse | 08952 |
| S1 | Power Switch | 23164 |
| U1 | Voltage Regulator, 7805 | 20699 |
| U2 | Voltage Regulator, LM320T-5 | 41876 |
| | Back Panel | 42986 |
| | Ckt Assy, Power Supply | 42903 |
| | Bracket, Instrument Cord Wrap | 43768 |
| | Bracket, Switch Support | 43052 |
| | Wrap, Switch Support | 43138 |
| | Fuse Holder | 03074 |
| | Power Cord | 24077 |

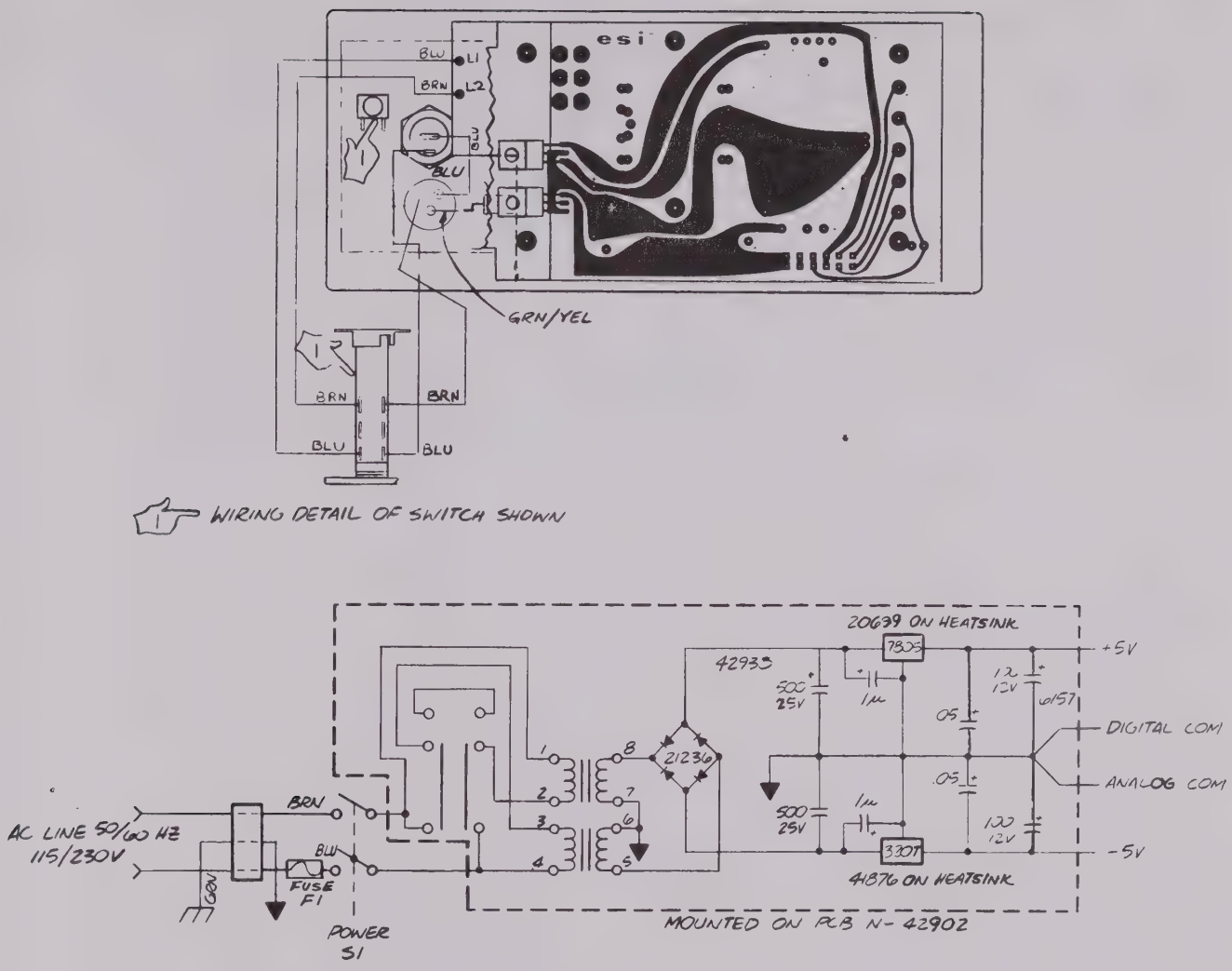



Figure 5-4. Rear Panel Assembly

## 5.5 POWER SUPPLY CIRCUIT ASSEMBLY (Part No. 42903)

| CIRCUIT NO. | DESCRIPTION | ESI PART NO. |
|---|---|---|
| C1, C2 | Capacitor, 500µF, 25V | 42938 |
| C3, C4 | Capacitor, 1µF, Tantalum | 06472 |
| C5, C6 | Capacitor, 0.05µF, Disc | 12116 |
| C7, C8 | Capacitor, 100µF, 12V | 06157 |
| CR1 | Bridge, Full Wave | 21236 |
| J3 | Connector, 6 Position | 43101 |
| S2 | Switch, Slide (230/115V) | 29233 |
| T1 | Transformer | 43303 |
| TB1 | Barrier Strip, 5 Position | 43079 |
| W1 | Cable Assembly, Chassis Ground | 44699 |
| | PC Board, Power Supply | 42902 |
| | Shorting Strap | 43308 |

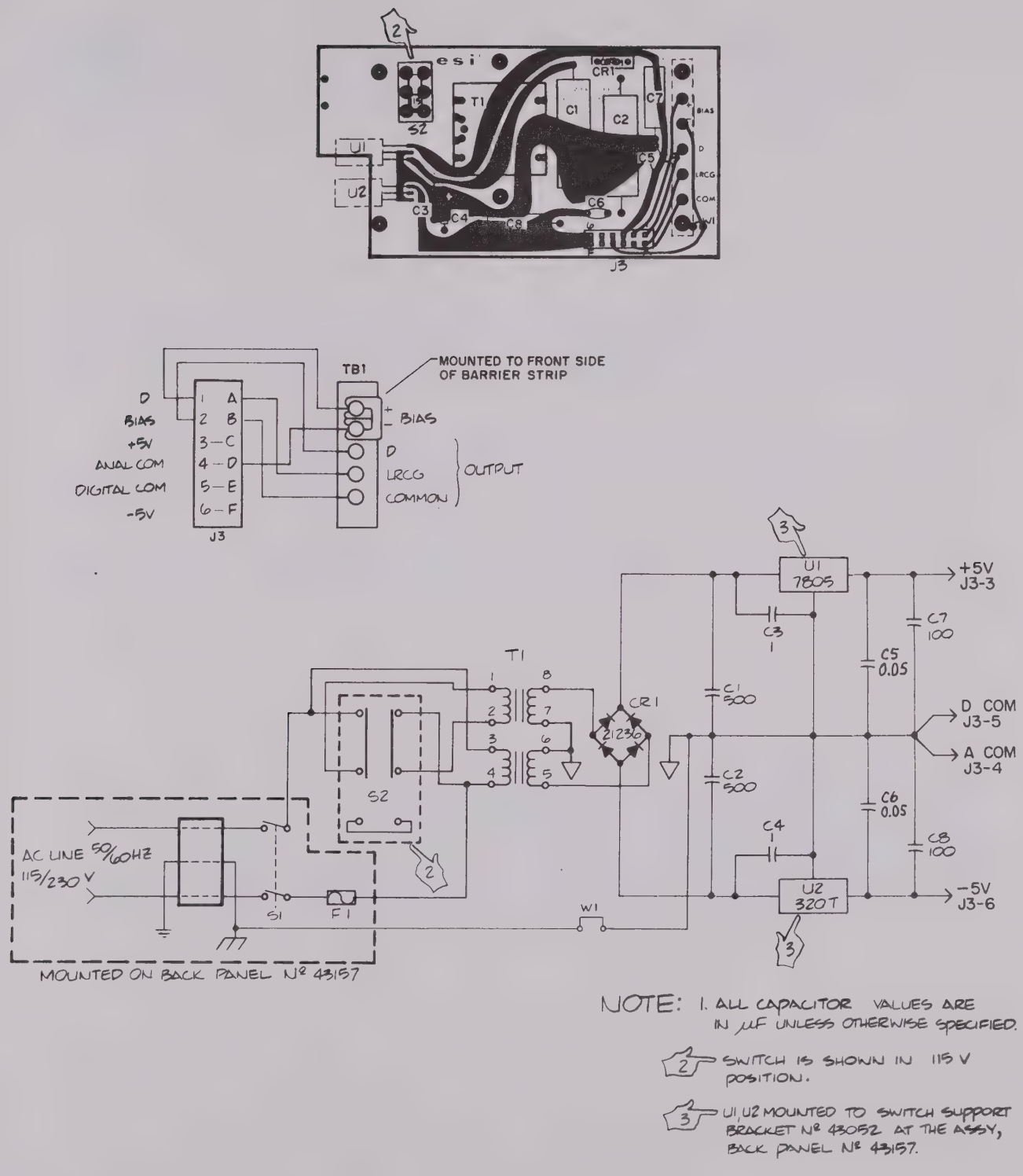



Figure 5-5. Power Supply

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## WARRANTY OF TRACEABILITY

The reference standards of measurement of Electro Scientific Industries, Inc., are compared with the U.S. National Standards through frequent tests by the U.S. National Bureau of Standards. The ESI working standards and testing apparatus used are calibrated against the reference standards in a rigorously maintained program of measurement control.

The manufacture and final calibration of all ESI instruments are controlled by the use of ESI reference and working standards and testing apparatus in accordance with established procedures and with documented results. (Reference MIL-C 45662)

Final calibration of this instrument was performed with reference to the mean values of the ESI reference standards or to ratio devices that were verified at the time and place of use.

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1. Two years for components and instruments utilizing passive circuitry. One year on repairs of out-of-warranty items.
2. One year on components and instruments utilizing active circuitry as identified in the price list. Six months on repair of out-of-warranty items.

During the in-warranty periods, we will service or, at our option, replace any device that fails in normal use to meet its published specifications. Batteries, tubes and relays that have given normal service are excepted. Special systems will have warranty periods as listed in their quotation.

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ESI technical publications are listed on the back of this page. If you would like any of these, simply check the appropriate box and fill in your address below. Also, please add any comments you have concerning the instrument or instruction manual. We value your feedback to help us improve or correct our manuals.

Instrument Description: Model No. _____ Serial No. _____
(Please Print)

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Department _____ Mail Stop _____

Company _____

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Comments or corrections _____

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*Attention: Literature Department*

- applications data
- technical articles
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☐ EB10 Effects of Output Loading on Resistive Voltage Dividers, *October 1969*

☐ EB15 Low Input Resistance Voltage Dividers, *February 1970*

☐ EB17 Accuracy vs. Frequency of Models 290B and 250DE Universal Impedance Bridges, *(revised May 1969)*

☐ EB26 International System of Units, *August 1969*

☐ EB29 DC and Low Frequency AC Ratio Measurements, *Dr. Merle L. Morgan, September 1962*

☐ EB30 Traceability of Resistance Measurement, *Jack Riley, January 1964*

☐ EB34 Resistance Transfer Technique, *Lawrence H. White, (revised April 1968)*

☐ EB35 An Improved Technique for Establishing Resistance Ratios, *R. M. Pailthorp and J. C. Riley, November 1962*

☐ EB41 Derivation of Electrical Units from Fundamental Standards, *R. D. Kuykendall and R. M. Pailthorp, July 1964*

☐ EB44 DC measurements Using Ratio Techniques, *Jack C. Riley, September 1965*

☐ TA2 A Ratio Transformer Bridge for Standardization of Inductors and Capacitors, *D. L. Hillhouse and H. W. Kline, August 1960*

☐ TA6 The Accuracy of Series and Parallel Connections of Four-Terminal Resistors, *Jack C. Riley, April 1965*

☐ TA8 AC Measurements Using Ratio Techniques, *Jack C. Riley, May 1965*

☐ TA14 The Advantages of a Ten Kilohm Transportable Resistance Standard, *Robert M. Pailthorp, September 1967*

☐ TA16 Which Bridge for Precise Resistance Measurements? *Edward J. Swenson and George D. Vincent, December 1967*

☐ TA17 Experimental Verification of the Five-Terminal, Ten-Kilohm Resistor as a Device for Dissemination of the Ohm, *R. M. Pailthorp and George Vincent, December 1968*

☐ TA22A Laser Resistance Trimming from the Measurement Point of View, *Arthur G. Albin and Edward J. Swenson, June 1971*

☐ TA23 Precision Measurement of Resistor Networks, *Robert M. Pailthorp and Jack C. Riley, June 1971*

☐ TA24 Predictive Adjustment of Tantalum Film Resistors by Anodization, *Donald R. Cutler and Edward J. Swenson, July 1971*

☐ TA25 Laser Trimming Analysis Using a Resistive Sheet Analogy, *Swenson, Vincent, Riley, December 1972*

☐ TA26 The Effects of Laser Trimming on Birox and 1100 Series Thick Film Composition, *N. S. Spann, R. Headley, G. D. Vincent and E. J. Swenson, October 1971*

☐ TA27 Laser Trimming Thin Film Precision Resistor Networks with an Automated System, *Leonhard Groth, January 1974*

☐ TA28 YAG Laser Trimming of Thick Film Resistors, *Headley, Popowich, Anders, January 1974*

☐ TA31 A Method of Obtaining Optimum Trimming Performance from a Laser System, *Paul F. Parks and Thomas W. Richardson, October 1974*

☐ TA32 Laser Trimming RC Active Filters, *Edward J. Swenson, April 1978*

☐ TA33 Reducing Post Trim Drift of Thin Film Resistors By Optimizing YAG Laser Output Characteristics *June 1978*